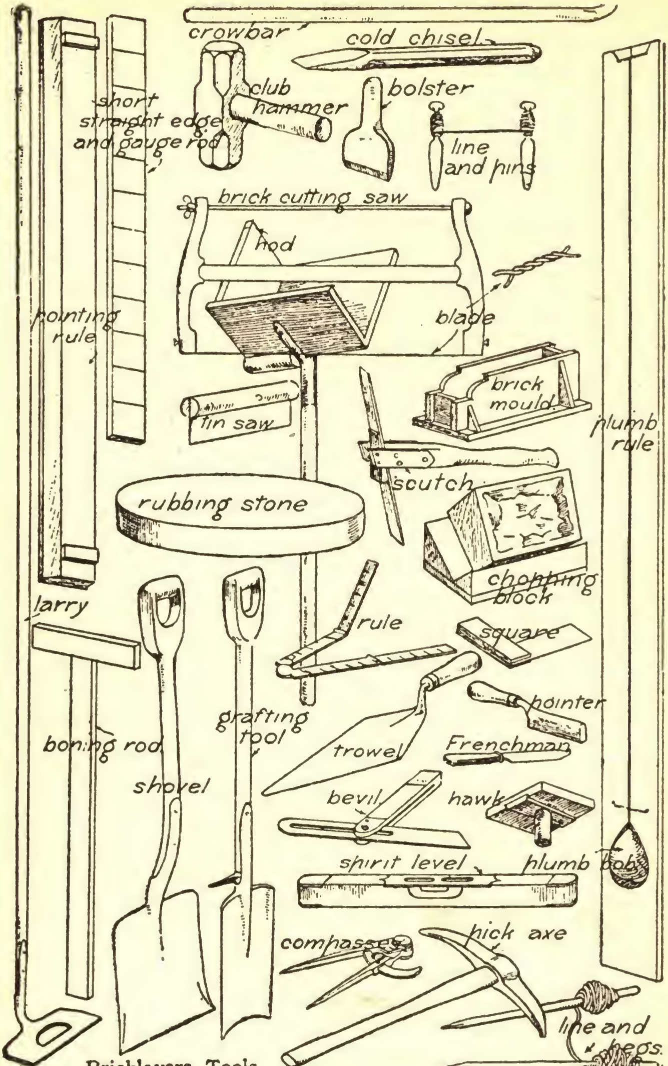
PRACTICAL BRICKLAYING
SELF TAUGHT

HODGSON

1907

Roland W. Lefavour.



Bricklayers Tools

FRONTISPIECE

PRACTICAL BRICKLAYING SELF-TAUGHT

ESPECIALLY DESIGNED FOR HOME STUDY

Being a series of exhaustive instructions in all kinds of bricklayer's work, including laying foundations, bonding, arching, gauged work, construction of damp courses, coping, building bridges, piers, chimneys, flues, fireplaces, corbeling, plain and fancy cornices, brick paneling, pilasters, plinths, and other brickwork, plain and ornamental.

By FRED T. HODGSON, Architect

Author of "Steel Square," "Modern Carpentry," "Architectural Drawing," "Modern Estimator," etc., etc.

ILLUSTRATED

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BRICKLAYERS' GUIDE

FOR THE BRICKLAYER

SOME DEFINITIONS

Throughout this work the terms "plan," "elevation" and "section" will be constantly used, and for the benefit of those who do not understand these terms the following definitions are intended:

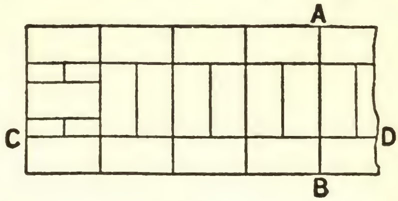


Fig. 1.

Plan.—A plan is a drawing representing any object as it would appear when looking down upon it. Thus, in drawing the plan of an 18-in. wall, not including the footings, draw the outside face lines and joints as in Fig. 1.

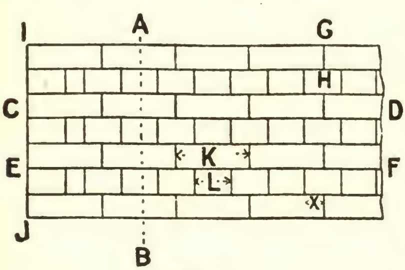


Fig. 2.

Elevation.—An elevation is the view of any object when looking directly at it. It may be vertical, or at any inclination to the horizontal plane. Elevations are known as front, back, and side; hence, again illustrating by means of the 18-in. wall, the front and back elevations would be shown as in Fig. 2.

Section.—A section is the view of an object representing it as it would appear when cut horizontally or vertically by a plane parallel or at any angle to the face or end. For instance, a vertical section, A B, through Fig. 2 would appear as Fig. 3.

Course.—A course is the name given to one row of bricks, in any thickness of wall, between two bed joints, as C D, Fig. 2.

Bed Joints.—These are the mortar joints between the courses, as E F, Fig. 2.

Cross Joints.—The short vertical joints at right angles to and connecting the bed joints are known as cross joints or perpends (see G H, Fig. 2).

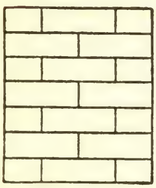


Fig. 3.

Transverse Joints.—When the cross joints are continued through the thickness of the wall they are called transverse joints, as A B, Fig. 1.

Wall Joints.—These are the joints in the thickness of and parallel to the face of the wall C D, Fig. 1.

Quoins.—The external angles of a wall are called quoins (see I J, Fig. 2).

Stretcher.—This is the 9-in. face of a brick, K, Fig. 2.

Header.—The 4½-in. end of a brick, L (see Fig. 2).

Bats.—The half of a brick is known as a 4½-in. bat, while any length above this and below 9 in. is known as a three-quarter bat.

Lap.—The horizontal distance between the cross joints in two successive courses is called the lap. This should never be less than one-quarter of the length of the stretcher, X, Fig. 2.

Closers (Kings and Queens).—A king closer is a brick

made to appear as a header on one end and a closer on the other (Fig. 4).

A queen closer is a brick cut, if possible, 9 in. in length by 2¼ in. on the face; most usually the 9 in. are made up of two 4½-in. lengths (Fig. 1).

Besides these, there are other closers that will be described later on.

The average length of a brick is 8¾ in., but with the addition of either a cross joint or a wall joint it is reckoned as 9 in.

The width is 4¼ in., and for the same reason as given above it is considered to be 4½ in.

The average thickness is 2¾ in, and four courses with the bed joints will measure 11½ in., 12 in., or 12½ in., etc., according to the thickness of the joints.

The usual practice is to build the work four courses to a foot.

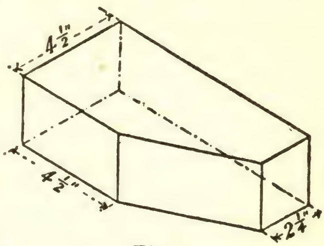


Fig. 4.

A wall 1½ bricks thick is usually called a 14-in. wall, 2½ bricks thick a 23-in. wall, whereas walls 2 bricks and 3 bricks thick are known as 18-in. and 27-in. walls, respectively.

FOUNDATIONS

The first thing to be considered in any brick structure is the foundation, and it is but proper we should devote some space at the outset to this important part of the subject. First we have, the necessity for foundations. Walls of buildings resting on ground of variable strength often fracture, due to the unequal

settlement of the work. To prevent failure in this manner the base of the walls of the building may be extended and supported by suitable foundations.

The object of foundations is to prevent inequality of settlement and distribute the weight of the structure equally over the substratum.

The bases of structures are invariably made wider than the superincumbent mass, to increase the stability and to counteract all the following damaging forces that tend to cause failure.

Damaging Forces.—The principal causes of failure are those which induce settlement, such as inequalities of earth resistance; the compressibility of mortar joints; lateral escape of soft soil, sliding of the substratum on sloping ground; the withdrawal of water; distributed lateral pressures, causing overturn, such as wind pressure, and thrust of barrel vaulting or of an untied couple raftered roof; concentrated lateral pressure which induces settlement and overturn, such as the thrust of framed floors, trussed roofs and groined vaults subjecting small areas of support to great pressures.

Inequality of Settlement.—Inequality of settlement in buildings takes place from two causes: (1) the compressibility of the mortar joints, (2) the compressibility of the soil.

An allowance of 1 in. in 24 ft. of brickwork in lime mortar is often provided for settlement, as in the example of the extremities of bridging joists of floors, at one end being supported by a brick wall and the other extremities by iron columns, etc.

Nearly all soils, with the exception of solid rock and gravel, are compressible under pressures often attained in buildings. It is therefore impossible, where large

buildings are erected on other soils, to avoid settlement; and the fact of any building settling is of no great import, provided the settlement be uniform and of no great depth, and the relative position of the parts of the structure unaltered. But where the resistance of the soil of every part of the site is not uniform, there is a risk of the above defect occurring, and special precautions must be taken to distribute the pressure to suit the varying strengths of the substratum.

Lateral Escape.—Heavy structures erected upon soft soils, such as running sands and peat, squeeze out from beneath the foundation, unless means are taken to confine the soil to the required area; this is usually accomplished by sheet piling, as described later.

Sliding.—This is a defect usually occurring where the building is erected on the slope of a hill, and the strata inclined, being depressed in the direction and towards the bottom of the slope. The weight of the building is liable to cause the strata to become detached and slide. This is prevented in two ways: (1) by driving piles at intervals to a considerable depth, thus connecting the strata; this method is often objectionable, tending, as it does, to shake and disturb the soil; (2) by building a retaining wall; this is the better method, as it not only supports, but also protects the strata from the effects of the atmosphere, which in soils easily affected by the latter is a desideratum.

Withdrawal of Water from Foundation Earth.—Edifices built on damp soil, such as a sand overlying a clay, have their stability endangered should the water be drained away after the building has been erected, as it will cause the foundation earth to occupy a less volume and in the sinking will tend to fracture or

overturn the walls; therefore the depth of the concrete foundation must be arranged below any probably adjacent cutting.

Distributed Overturning Pressures.—Distributed forces acting upon the upper level of walls, such as the continuous pressure of barrel vaulting and the spreading tendencies of untied couple raftered roofs, and also the distributed pressures on wall faces, such as wind pressure, tend to cause failure in two ways: (1) by overturning, the minimum resistance being generally at the change of section, usually at the ground level; (2) by subjecting the leeward edge of the wall to the pressure sufficient to crush the material or by throwing the weight on a small area of the substratum, forcing it from its original position and causing a settlement.

The stability of walls when subjected to such distributed overturning pressures is treated in the chapter on that subject.

Concentrated Lateral Pressure.—The thrust caused by united principals, as groined faults or other forces acting at a point or along vertical lines on the wall, are often resisted by buttresses.

Atmospheric Action.—Many otherwise thoroughly reliable soils are practically reduced to the condition of mud if exposed to the effects of the atmosphere or to rain water. The variation in temperature at the different seasons also causes the ground to expand and contract considerably.

Where foundations are constructed in such soils, they must be taken sufficiently deep to be beyond the effects of the atmosphere, that is, below the line of saturation. Four feet below the ground level is usually sufficient for this purpose, the soil below this not being

affected to any appreciable extent by the percolation and subsequent freezing of rain water.

The line of saturation in the section of any part of the earth's crust represents the depth to which the soil at that part is saturated by the absorption of rain water and affected by atmospheric changes.

Excavations.—Before commencing any constructional work in connection with a building it is necessary as the first operation to carefully take the levels of the site, in order first to arrive at an estimate of the amount of earthwork to be done; and secondly, to determine the design of the basement story, this latter often being materially affected if the differences in level of the various parts of the site are great. The next operation is to level the ground. This in most instances consists in excavating and removing parts of the site, and in depositing earth in other parts to form embankments or to fill up hollow places. In order to conduct these operations in the most economical manner the levels must in all instances be taken and plotted with the greatest accuracy. This can only be efficiently done on areas of any magnitude by means of the surveyor's level, the method of employing which will be described later. All leveling operations for ordinary constructional work may be carried out by referring them to the principles laid down for performing the three following operations:

1. Taking levels of site.

2. Leveling the bottoms of trenches for drains or foundations.

3. Embanking for roads or leveling of depressions.

Instruments.—The instruments required to determine the levels of the site are: first, the surveyor's level;

second, the measuring staff; third, ranging poles and chain or tape.

Methods of Leveling.—Taking the levels of a site may be carried out in one of three ways: First, by taking a number of section lines across the site; secondly, by erecting the level in a commanding position and taking the relative heights of the salient points and noting them on plan (this method is only applicable for small sites); thirdly, by contours.

In all three methods it is necessary to have a datum level to commence from, and from which all other levels can be referred. A line on some permanent structure in the immediate vicinity is usually taken, or if such does not exist, a stout stake is driven in the ground in a position away from the work where it is not likely to be disturbed.

First Method.—A number of sections are ranged across the site, each line being numbered or lettered; the level is then set up on or in close proximity to the first line and the datum; the measuring staff is then held by an assistant on the datum point and then on the extremity of the line, the relative heights of the two points being recorded in a field book kept for that purpose. A number of points on the line are then taken, and the measuring staff is held over them and their relative heights are recorded, and their distances from the beginning of the line are measured. When the bottom of the measuring staff rises above or the top becomes depressed below the line of sight through the rise or depression of the ground, the level must be moved further along the line and the preceding operations repeated. Fig. 5 illustrates the method. The following is a form of field book with the reading for a section entered:

Fig. 5.

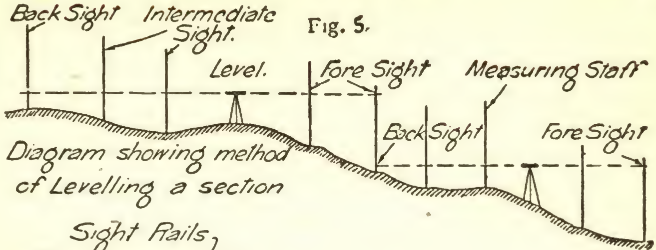


Diagram showing method of Levelling a section

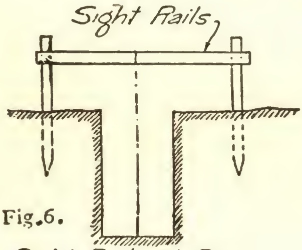


Fig. 6.

Sight Rail with Posts fixed in ground

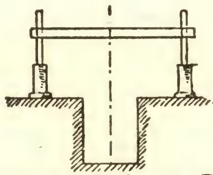
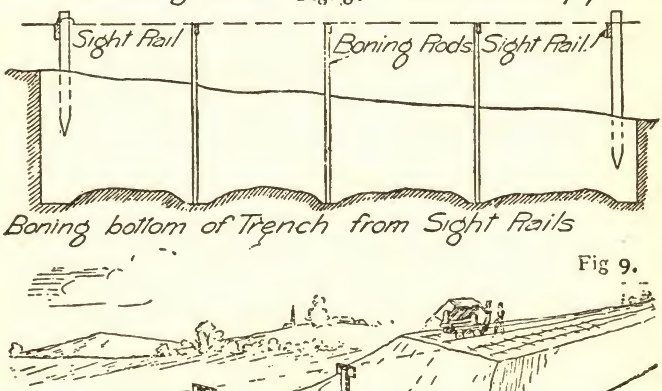


Fig. 7.

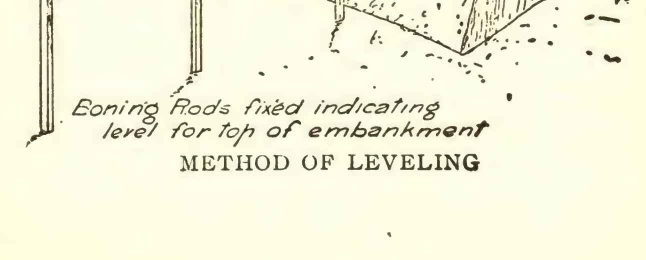
Sight Rail with Posts fixed in drain pipes

Fig. 8.



Boning bottom of Trench from Sight Rails

Fig 9.



Boning Rods fixed indicating level for top of embankment

METHOD OF LEVELING

FIELD LEVEL BOOK

Back Sight.	Inter. Sight.	Fore-Sight.	Rise.	Fall.	Reduced Levels.	Distance.	Total Distance.	Remarks.
						chains		
4.15	......	......	......	....	100′.0	.....	......	Bench Mark A
	4.13	......	.02	....	100.02	1	......	1 peg
	5.01	......	.....	.88	99.14	2	.....	2
	4.86	......	.15	....	99.29	3	......	3
	6.06	......	.....	1.20	98.09	4	......	4
		8.02	.....	1.96	96.13	5	......	5
12.25								
	8.46	......	3.79	....	99.92	6	......	6
	3.04	......	5.42	....	105.34	7	......	7
		2.15	.89	....	106.23	7.57	......	Bench Mark B
12.60								
	7.19	......	5.41	....	111.64	8.57	......	8
		2.53	4.66	....	116.30	9.57	......	9
9.37								
	5.75	......	3.62	....	119.92	10.57	......	10
		3.94	1.81	....	121.73	11.57	11.57	Bench Mark C
			25.77	4.04	21.73			
			4.04					
			21.73					

The above shows a typical field book. The reduced level of the first point is taken as 100 ft. above a datum level; the levels are all read in feet and hundredths of a foot; the distances are taken in chains and links, but may be taken in feet and inches. The rise and fall columns should be balanced, also the first and last reading in the reduced levels; these two quantities will equal each other if the computations have been correctly made.

Second Method.—The second method is evident from the previous explanations.

Third Method.—The method of contouring is the most useful, but takes the longest time to perform it;

it consists in describing upon a plan a series of level lines with a uniform vertical interval between them. To carry out this operation it is usual to erect the instrument on the highest point of any section of the area to be contoured, and from this point to range a number of lines radiating from it, their direction being fixed by taking their bearings. The height of the instrument is then taken, and the man with the measuring staff is directed up or down each line in succession until a number of points of the required vertical interval and their distances from the initial point are determined. This method is most useful for laying out large estates where extensive works are projected, as on such a plan the problems of drainage and roads of convenient and economical gradients can easily be laid down.

When the levels of a site are known, and the building is planned, and the position of one of its leading lines is determined, to set out the remaining lines of an ordinary building becomes a simple matter, only requiring great care in the measurements of the parts. If the setting out is rendered difficult through differences of level in the paths, a theodolite would very much simplify the operations.

Boning Method of Leveling.—This operation is used for the leveling of trenches, ground work, paving, etc. There are three rods in a set; two of these are leveled at a distance of about 10 ft. apart; a third rod is then leveled at a similar distance, taking care to reverse the long level. The center rod is then removed, and the level transmitted to any point along the line by sighting or boning over the first and third rods.

Fig. 10 shows the method of using boning rods and setting a curbstone.

Trenching.—When the lines of the building have been laid down and all its salient angles pegged out, the work of excavating the trenches commences. It is absolutely necessary that the trenches should be level along their bottoms. To ensure this, two or more sight rails (as shown in Figs. 6 and 7) are erected over the trench; it is necessary that the side posts of these should be fixed in such a position that they shall not be disturbed by any of the subsequent operations.

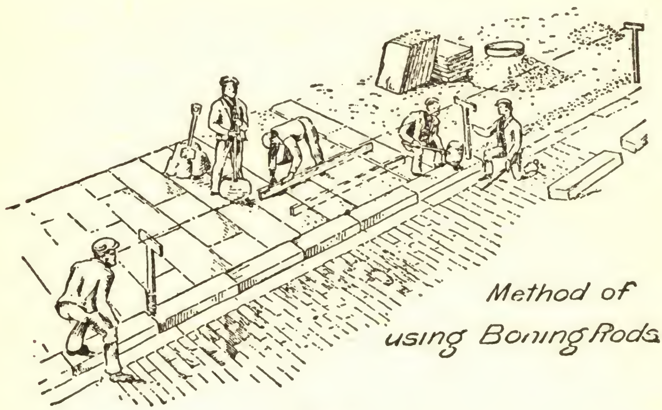


Fig. 10.

A level line is sighted through the level and marked on the sight rails; the cross bar is then fixed on each, and a mark is made on the bars plumb over the center of the trench. The width of the trench is marked out with the line and pins (see Fig. 9), and the excavation is carried on, timbering being inserted as the earth is removed, if required, by one of the methods afterwards described. When the full depth of the trench has been nearly reached, a number of points

are sunk to the exact depth by means of boning rods, the top of which is sighted between two of the sight rails, as shown in Fig. 8. The remaining parts of the trench bottom are then taken out level between the points so determined. A similar process is pursued for sinking a trench for a drain, the variation being that the sight rails have a difference in height necessary to give the required fall.

Embanking.—The method of forming an embankment is as follows: The center line of the proposed work is ranged out on the ground, and at equal intervals along the line boning rods are erected, the two extreme rods being first fixed either level or with a difference in height sufficient to give the required gradient; a rod is then erected on each of the intervals determined upon, and boned between the two extreme rods. The embankment is then commenced from one end, the earth being tipped in from carts or wagons until the tops of the boning rods are reached; sufficient earth in excess must be allowed for to compensate for compression and settlement. The width of the embankment is completed as the work is pushed forward, as shown in Fig. 9.

Timbering for Excavations.—It becomes necessary, where earth has to be excavated to any considerable depth, for foundations or other purposes, to support the sides of the cutting until the sinkings or trenches are filled in, or other action taken to permanently support the sides. This end is attained by means of timber shores, the arrangement of which is modified and governed by several conditions, such as the nature of the soil, the size of the cutting, and the special peculiarities of the particular piece of work under consideration.

There are three typical methods of strutting used for supporting the sides of narrow trenches excavated

Fig. 11.

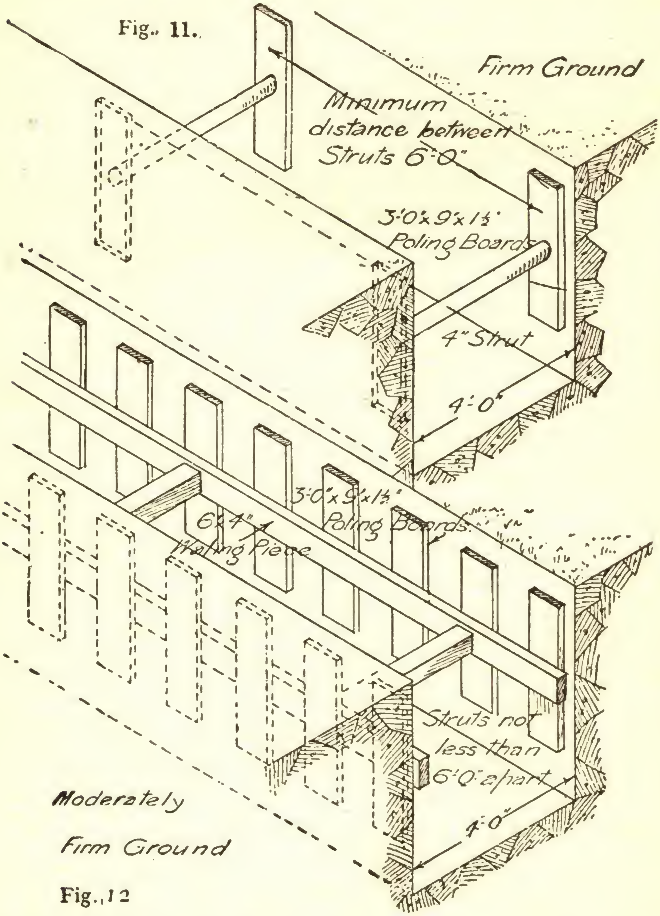


Fig. 12

for foundations or drainage work, shown in Figs. 11 and 12.

The first, used for firm ground, consists of short upright members, termed poling boards, out of $9 \times 1\frac{1}{2}$ in., usually from 3 to 8 ft. long, placed in position in pairs, one board on each side of the cutting; these are kept apart by struts out of about 4×4 in., or short ends of scaffold poles cut and driven tightly between the poling boards. The strutting is fixed as soon as the trench has been made sufficiently deep. The horizontal distance apart between the adjacent system of strutting varies according to the cohesive strength of the soil, but never less than 6 ft., which is just sufficient to allow a man to work in with effect.

The method shown in Fig. 12 is adopted where the earth requires to be supported at shorter intervals than 6 ft., and consists of upright poling boards and struts as before, but with the addition of a horizontal timber termed a waling piece. The process of fixing is as follows: The cutting is made, commencing at one end, and as soon as sufficient earth has been excavated a pair of poling boards and struts is inserted as in the first method; this process is repeated, fresh poling boards being fixed at distances apart varying with the nature of the earth, these distances being in some instances very short.

Horizontal members, 4×4 in. or upwards, are placed one on each side of cutting and strutted tightly against the poling boards. After about 12 ft. has been thus cleared, the struts which were fixed first are then knocked out; a fresh depth is commenced, and treated in a similar way.

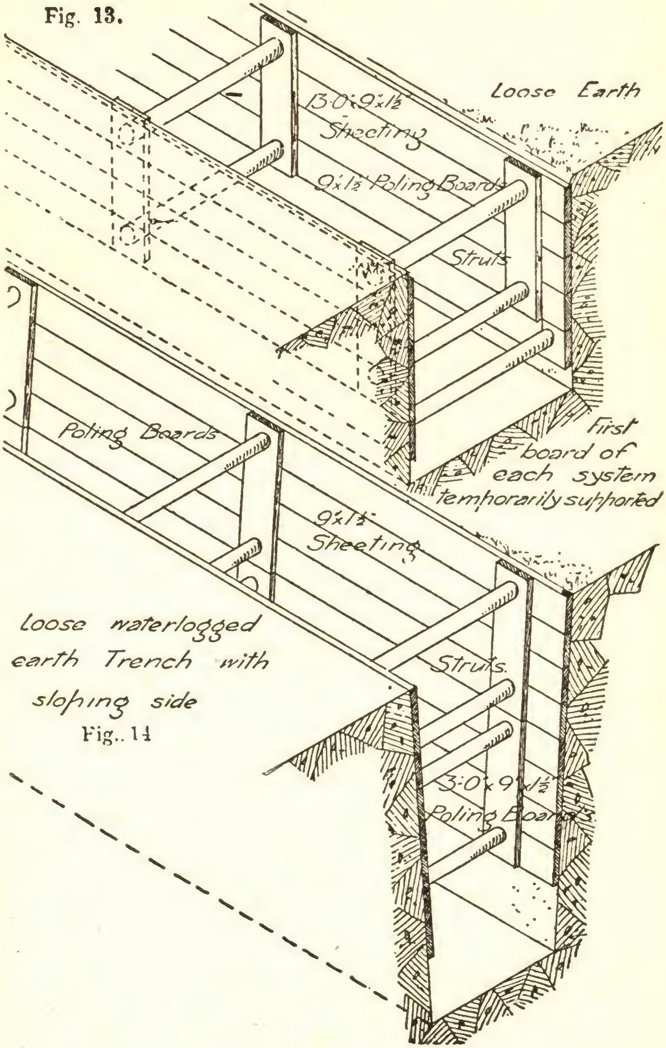
The third method is employed where the earth is very soft, and consists in laying horizontally boards, usually $9 \times 1\frac{1}{2}$ in., against the sides of the excavation; the boarding laid in this manner is termed sheeting,

which is supported by upright poling boards and struts, as shown in Fig. 13. The method of fixing is as follows: The earth is taken out to a depth of 9 in., and a pair of boards is inserted and strutted apart; another depth of 9 in. is then taken out, and sheeting fixed as before. This process is repeated until a sufficient number of boards has been inserted, usually four; upright poling boards are then placed in position against the sheeting and strutted apart, as shown in Figs. 9 and 10; the first fixed struts are now struck and cleared away.

The above system may be improved upon, when the depth of the cutting is not too great, by cutting the sides of the excavation to a slight batter, as shown in Fig. 14; by so doing th timbers are prevented from falling should the earth contract on becoming drained; it also facilitates the fixing of the struts.

Large Cuttings.—Continuous trenches, if made in bad ground, are generally arranged as shown in Fig. 15. At intervals guide piles are driven in, to which walings are bolted, and sheeting consisting of boards about 10 ft. long, shod with iron, termed runners, inserted between; these are driven a short distance into the ground, the earth between the two systems of piles being then taken out, and care taken not to excavate within a foot of the bottom end of the runners, which are again driven in and the process repeated. After the excavation of the first part, wales, consisting of whole timbers, are placed in position and strutted apart, the struts being also of balk timber. Long struts are supported in the direction of their length by short uprights secured to them by dogs. Uprights are also placed between the waling pieces as each fresh one is inserted.

Fig. 13.



loose waterlogged earth Trench with sloping side

Fig.. 14

After the ground has been excavated to the depth of the runners, a fresh system of piles and runners is driven slightly to advance of the former system, and the ground excavated as before. Cuttings are made in firm ground by excavating the earth and using ordi-

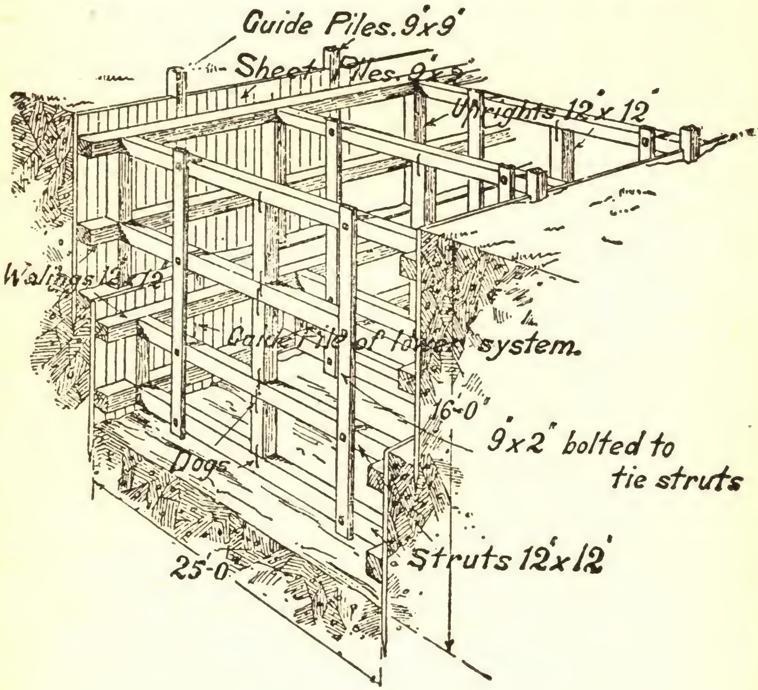


Fig. 15.

nary sheeting, but if the cuttings are required to exceed 30 ft. in width, it is found to be more economical to adopt a system of raking shores.

The method illustrated in Figs. 16 and 18 is employed where the ground is soft and waterlogged

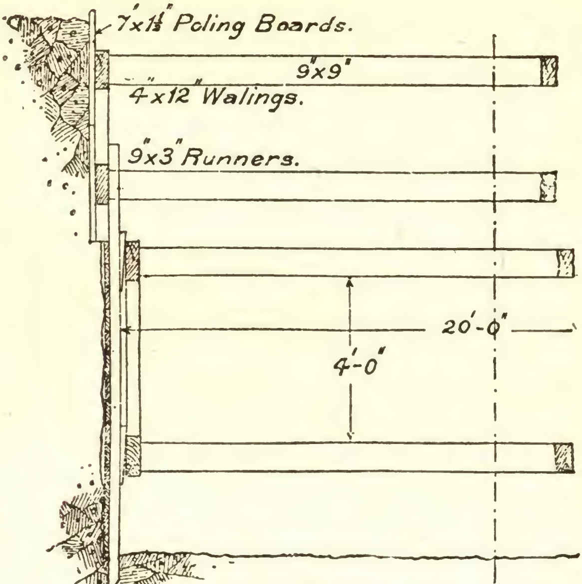

7"x1½" Poling Boards.
9"x9"
4"x12" Walings.
9"x3" Runners.
20'-0"
4'-0"

Fig 16.

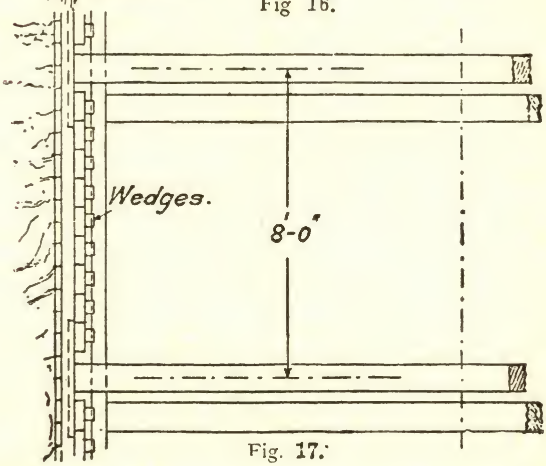

Wedges.
8'-0"

Fig. 17.

and is especially suitable for running sand. By this method as much of the earth is taken out as is possible without the sides of the excavation falling in, generally from 4 to 6 ft.; this is then supported by upright sheeting, waled and strutted. The excavation is continued by lining the cutting with a secondary system of runner, i.e., battens 7 × 2 in., pointed at lower ends

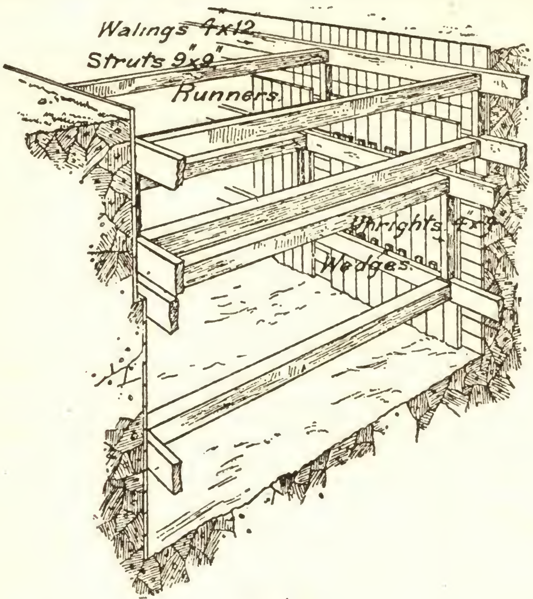


Fig. 18.

and of about 9 ft. in length. These are waled and strutted. Between each runner and waling piece a wedge is inserted. The method of proceeding with the excavation is as follows: The wedges securing one runner are loosened, the earth from the foot removed to a depth of about 12 in., the runner being dropped as the ground is removed and re-wedged. Each runner

is successively treated in this manner till the whole system has been lowered the necessary amount. It is essential that the feet of these runners should be at all times kept in the ground, as, if any portion of the vertical side of the excavation be exposed, the earth is liable to ooze out and leave the back of the runners unsupported and cause the whole system to collapse.

Sinking Shafts.—It is often necessary to sink shafts for foundations, etc. These are made from 4 ft. square and upwards, the former being the smallest size a man can work in without difficulty.

Shafts from 4 to 9 ft. square are timbered as shown in Fig. 19.

In ordinary soils the earth is excavated to a depth of at least 3 ft., and in firm soils 6 ft. The sides of the excavation are then lined with vertical sheeting, consisting of boards 9 in. wide, 1 to 1½ in. thick, strutted apart by frames of horizontal waling timbers, a pair of which is placed in position against two opposite sides, and strutted apart by another pair driven tightly between and against the remaining sides, these being secured by cleats nailed to the fixed waling pieces. Another depth of earth is then taken out and a second system of sheeting placed in, the upper ends of which lap about 1 ft. over the lower ends of the first system of sheeting; another frame is placed in position as before, securing both systems of sheeting. Uprights are fixed in the angles between the waling pieces, and often at intermediate positions along their length. This process is repeated till the required depth is obtained,

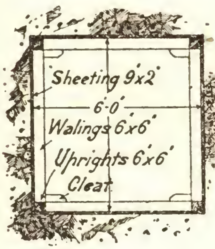


Fig. 19.

The timbering requires to be supported if the depth be great, to prevent it from sliding down on the removal of the earth from its lower end. Where this has to be done, the upper end of the shaft is left projecting about 3 ft. above the ground level. The two first fixed waling timbers at the ground level are continued through the shaft, and project several feet on either side, a good bearing on the solid ground on both sides of the shaft being thus obtained, as shown in Figs. 20 and 20A.

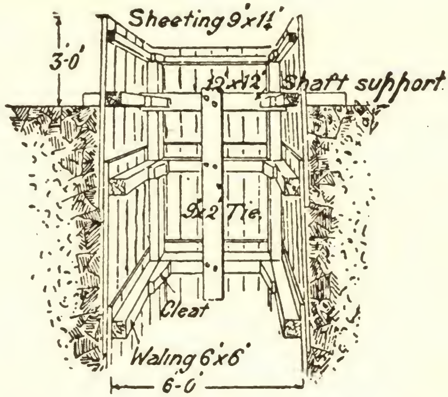


Fig. 20.

These members are usually out of square timbers; they are strutted apart as described. An upright vertical timber is notched over this, and spiked to the face of the waling timbers below, the whole being thus tied together.

These are often supplemented by similar timbers at the bottom of the shaft. These timbers are fixed in two pieces, with a scarf in the center; they project about 3 ft. into both sides of the pit. A chain is

sometimes employed in addition to the timber spiked to the walings.

Intermediate struts are required to support the horizontal walings where the size of the pit is above 9

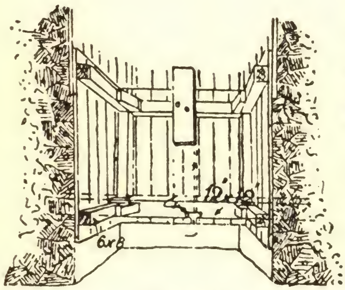


Fig. 20A.

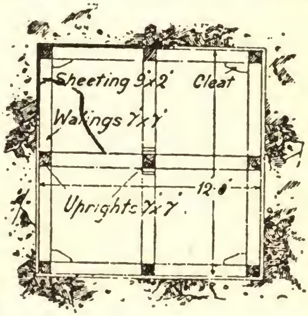


Fig. 21.

ft. square. One system of struts is fixed between two opposite sides, being supported at their ends by cleats, as shown in Figs. 21 and 23; these being necessary to prevent the timbers falling should they become loose

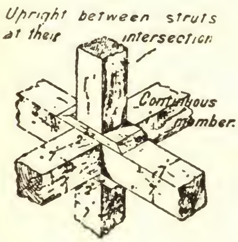


Fig. 22.

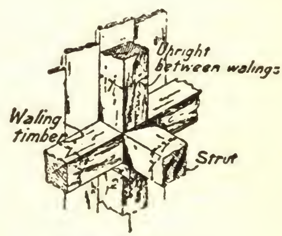


Fig. 23.

during the progress of the work. The struts that support the remaining sides intersect by butting, as shown in Fig. 22, against the first system, and are therefore fixed in two pieces. The struts at their

intersection are supported by uprights, on the upper ends of which short ends of timber are placed, projecting beyond the sides, acting as corbels, and forming a ledge upon which the shorter struts take a bearing.

The earth is raised from the bottom of the shaft, if of a great depth, by means of hoisting tackle; but if the cutting be shallow, stages are often erected in 6 ft. heights, the earth being shoveled from one to the other till the top is reached.

Tunneling.—In building operations it is often necessary to bore a tunnel in order to construct drains, etc., the process being carried out as follows:

Tunnels are made just large enough for a man to work in, that is, from 4 to 7 ft. square. The earth is taken out in sections of about 3 ft. at a time, poling boards of the same length being then placed against the upper surface, and kept in their position by a system of strutting, consisting of a head, sill and two uprights, out of either round or square timbers. The sill is placed in position first, being partly bedded in ground to prevent lateral motion, and being bedded in its correct vertical position by boning through from the sills previously bedded; the head next, then the struts, which are cut and driven tightly between the two. The next section is then cleared out, commencing at the top, just enough being taken out there to allow of the next system of poling boards being inserted, these being arranged to overlap the first system at their back end, the two being then strutted up together; this process is repeated till the tunnel is finished.

If the soil be bad and the sides liable to fall in, they must also be lined by poling boards, these being kept in their place by the uprights.

Large spikes, similar in shape to floor brads, are

driven into the head and sill, with their heads left projecting so as to be easily withdrawn, to secure the struts when in position. Wood cleats are often used in place of these.

These tunnels are usually made slightly tapering from the base to the head, as shown in Figs. 24 and 25.

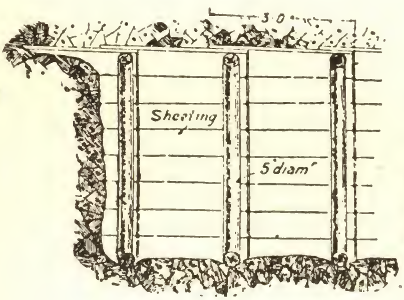


Fig. 24

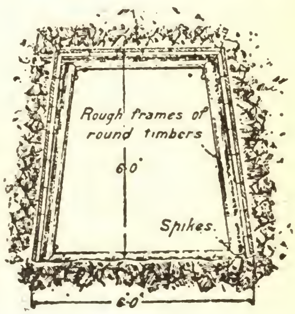


Fig 25.

Foundations.—The construction of foundations varies with the nature and bearing strength of the soil. The following are the ordinary soils met with in practice and the method of treating them: Rock, chalk, gravel, clay and sand.

Rock.—Foundations laid upon the solid rock are undoubtedly secure, as far as settlement is concerned; such a substratum being practically incompressible. Rocks often have fissures and defective parts, and all gaps must be filled up with concrete, any unsound parts being cut away. Rock foundations are very expensive in working, owing to the extra labor involved in cutting them; but where they occur they may be built upon direct.

Chalk.—The sites for buildings on chalk or marl soil should be drained, and precautions taken to prevent

them becoming wet. Where this can be done, the structure can be built upon the chalk or marl direct, after it has been leveled; but where heavy buildings are erected, or great weights concentrated, concrete should be employed to distribute the pressure.

Gravel.—Where lateral movement is not likely to occur, gravel is one of the best soils to build upon; it is not affected by the action of the atmosphere, and is practically incompressible.

Clay.—Clay is a good soil to build upon where the foundations are taken deep enough to be beyond the action of the atmosphere. Clay is very subject to expansion and contraction with the variations in temperature, and is therefore dangerous to build upon unless protected.

Sand.—Sand is a good material to build upon, if it can be kept dry and confined laterally; if subjected to the effects of running water it is liable to be scoured from about the foundation.

In all the above soils, with the exception of the rock, and the chalk when in a good condition, it is usual to form a bed of concrete, the area of which is proportioned to the weight to be carried and the bearing strength of the soil.

The following are cases that require special treatment: (1) Soft soils of a great depth; (2) soft soils with hard strata beneath; (3) soils not having a uniform resistance, formed of rocks which have hollows or fissures filled up with some softer material. As this work is intended to be more of an elementary and practical work than otherwise, the foregoing will be quite sufficient on the preparation of trenches, cuttings and excavations for foundations, at least for the present.

In preparing footings on which to lay bricks, care must be taken to keep the work in line and fairly level on top before the brickwork is commenced, whether the lower footings be of stone or of concrete. At this writing, concrete seems to be the popular material in use for the lowest layer of foundation, and justly so, as, when properly put in place, and the proportions of the various materials wisely assigned and mixed, the work will be as though one solid stone was laid all round the building on which the brickwork may be placed. An illustration of the proper method of laying in a concrete footing is shown in Fig. 26, and one that has been adopted in many an architect's office and many a municipal building department. Taking the wall in section and extending the concrete each side of the bottom course of footings, drop perpendicular lines as outside width of concrete, the depth being determined by an angle of 45 degrees, passing from the point A of the next work, and cutting the outside line of concrete. A cubic yard of concrete would require 27 cu. ft. of broken brick, stone or shingle, 9 cu. ft. of sand, 4½ cu. ft. or 3½ bu. of Portland cement, and 25 gal. of water. These quantities should be correctly measured, turned over together three times dry, and again several times while the water, through a hose, is being sprinkled over the mass. Broken brick or stone small enough to pass through 1½-in. mesh is preferable for the aggregate. The practice of throwing in concrete from a height, in

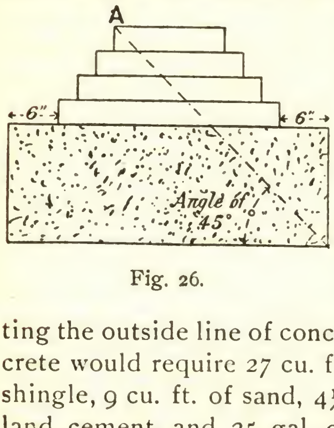


Fig. 26.

order to consolidate the mass—which used to be considered essential, even when staking had to be erected and the stuff wheeled up to the required height at considerable expense—has now exploded. It should be brought on to the side, deposited and lightly punned or beaten down with wooden rammers, but only just sufficient to bring the moisture to the surface; if rammed too much the cement comes up with the water. If, however, it is more convenient to tip the concrete into an excavation, no sensible injury will be done to it.

The objection that, in falling, the heavier particles separate from the finer is, from the very stickiness of the mass, more theoretical than practical, and, at the most, applicable only to each separate barrow load tipped in, and not to the whole bed. Sliding it down a wooden shoot, however, should never be permitted, as the cement and small stuff cling to the sides and run down in a muddy slush; whilst the stones are shot out into a separate heap by themselves.

In ordinary foundations the concrete should be deposited in horizontal layers, about 2 ft. thick, and care should be taken to cover any joints in one laver by the succeeding one, as the joint between two days' work is always a weak part; moreover, the last layer should be well wetted to insure a proper connection with the next.

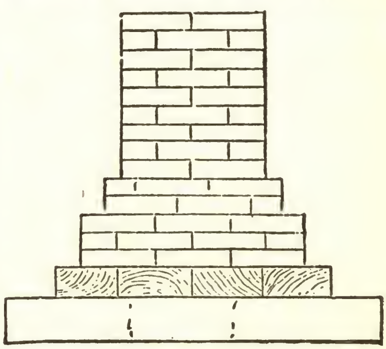


Fig. 27.

Sections of Footings and Walls in English Bond.

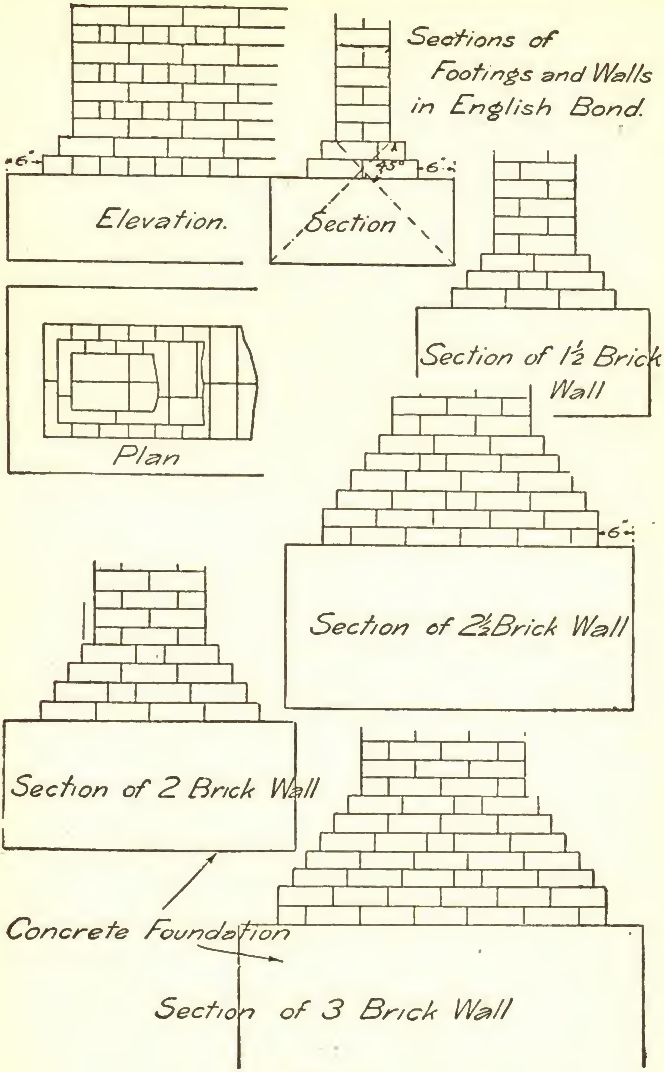


Fig. 28.

In Fig. 27 an illustration is shown of a wall and footings, the latter being of stone, not less than 6 in. thick. On the lower footing of stone is laid another course of stonework, and on this is laid the brickwork, the top of the upper stone being made level and a layer of good mortar spread over it so that the bricks have a good bed to rest on. This layer should be cement mortar where possible, as it would help to make the whole work stronger and better.

Fig. 28 shows five sections of brick walls and footings, with the methods of arranging the bricks in the wall; there being a one, a one and a half, a two, a two and a half, and a three brick wall, showing the proportions for concrete footings. A scale in feet and inches is shown on the page, so that the proper measurements may be taken off for actual use. A fact worth considering. All these examples are in English bond, but are good for any other bond.

Having dealt with foundations and footings, as we hope, in a satisfactory manner, it will not be out of place to say a few words on damp courses and means of preventing damp from getting up into the walls of buildings.

DAMP COURSES

In the construction of walls for dwellings, or in fact any other building of importance, it is essential that damp be prevented from being drawn up into the body of the wall by attraction; and the first thing to do in this case is to give some careful consideration to the floors, walls and footings of the cellar. Much has been written on the subject, and many recommendations of more or less value made as to the means of its prevention. Whether or not many of these are expe-

diencies and not cures, the conditions in each case must decide.

All building materials, with perhaps the exception of granite, are porous and capable of absorbing and transmitting moisture in large quantity. The dampness in our dwellings, however, arises from a variety of causes; from absorption of moisture from the soil in or on which the building stands (a clay soil being peculiarly bad in this respect); from imperfect joints at window sills and lintels, as also unfilled and unpointed joints on the face of the wall; from moisture, forced into the walls during heavy driving rain storms; and from the water used in the process of construction, in the mortar and plaster, the wetting of brick, etc.

Every damp-preventing device, therefore, should be twofold in nature; it should, first, preclude the moisture from getting into the walls, and second, should not hinder it from getting out of the walls. The former is to be accomplished by an absolutely waterproof covering, such as asphalt or tar, or the complete isolation of the wall from any sources of dampness (exception, of course, being made here to the moisture which is *put* into the walls in building, and which should be allowed a proper opportunity to dry out). The latter is assured by the perfect ventilation of the walls on all sides.

The remedies for the dampness arising from the several causes above noted will be studied in their proper relative places.

There are many devices for keeping moisture from entering the cellar walls, and they may be divided into applications to the outside of the wall, and constructive devices. The efficiency of the former depends, in

large degree, on the care and thoroughness with which they are applied. Of this class we have rock asphalt, tar and cements. The first and second are applied to the wall with a large brush and must, obviously, be boiling hot. The coating must be not less than three-eighths of an inch thick, covering every joint, and be carried down to the bottom of the footings. To ensure perfect protection, the wall should have been built as carefully as possible, the joints well pointed, the whole to have become well dried, and the asphalt or tar applied in two or more coats. The coatings should not stop on the face of the wall, but be carried entirely over the top, Fig. 29. Some builders recommend that the asphalt be mixed with linseed oil.

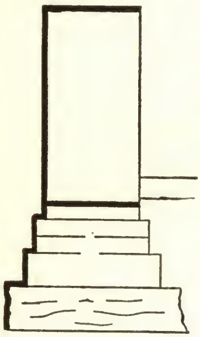


Fig. 29.

Concerning cement as a guard against water, opinions now differ. That it is an excellent protective covering when it is well and thoroughly applied is not to be questioned. It is, however, frequently fractured by the settlement of the walls, and, being to some degree porous, suffers from the action of the frost. In either case it has no further value as a protective. To lay it properly, all the joints and beds of the wall should be raked out at least one-half inch deep. The coating should not be less than one-half inch thick, and should, as far as possible, be applied all at one time. If it is necessary to make a joint it should be vertical and not horizontal. The last precaution is that the earth must not be filled in against it until the cement has thoroughly set. A similar protective

covering is made of a concrete of one-half lime mortar and one-half good cement (Portland preferred).

Of constructive devices to guard against dampness we have, first, those that are in the wall itself, and comprise the horizontal damp courses, hollow brick lining and facing and hollow wall.

The horizontal damp courses are of several kinds, and are placed at the bottom of the wall either on top of the footings or a short distance above them. The most effective course is one of asphalt or tar, Fig. 29, applied in coats in the same manner as described for the facing of the walls. A greater degree of efficiency is given by laying the course of bricks immediately above the damp course, while the last coat is still hot and soft. When this damp course is set in a stone wall it would be better to lay a course of bricks and on this place the asphalt course, starting the stonework above the latter, Fig. 30. A layer of slate, set in cement, has been much employed as a damp course. It has, however, the disadvantage of being very liable to fracture under uneven pressure. Sheet lead is a most excellent damp course, and has been applied to the purpose for two centuries. For ordinary work its cost precludes its use.

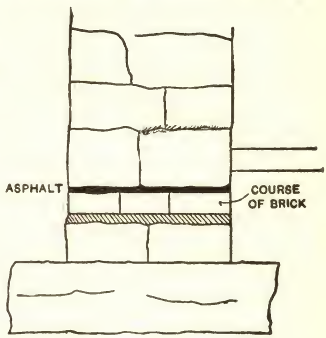


Fig. 30.

It is claimed that the penetration of moisture can be hindered by building the wall so that there are no continuous bed joints through the wall. This device

is presented on its own merits, the writer having no personal knowledge of its efficiency.

Another excellent damp course is found in the use of perforated terra-cotta bricks. These are made the same size as the ordinary brick, and can, therefore, be readily bended into the wall. A course may be set immediately above the footings and another at or near the top of the wall. The bricks should be laid so that the openings run through the wall and so allow of ventilation and evaporation of any moisture that might

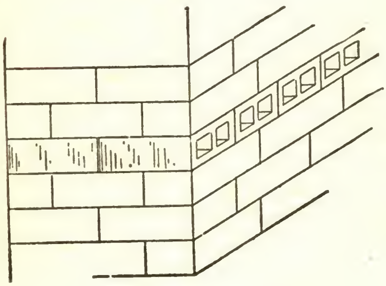
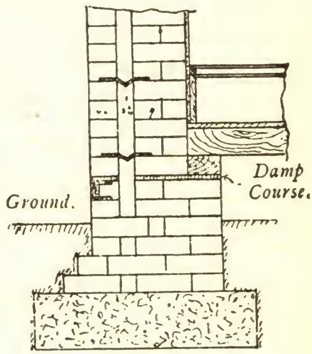


Fig. 31.



Section.

Fig. 32.

rise in the hollow bricks themselves, as shown in Fig. 31. The perforated bricks are also used to form a vertical damp course. They may be placed either on the inside or outside of the wall and may be laid as stretchers, as there is not the same liability to collect and retain moisture as there is in the horizontal course. Headers should be placed at frequent intervals to bond the facing to the body of the wall.

A simple and somewhat inexpensive system of rendering walls absolutely damp-proof and of adding very

much to their strength and stability is to build the brickwork in two 4½-in. thicknesses with a ½ or ¾-in. cavity kept clear of mortar. Thin boarding is inserted in the cavity as the work advances, the space being afterwards filled with rock asphalt compositions. The compositions answer the double purpose of binding the two thicknesses together and making the wall impervious to moisture. A section of such a wall is shown in Fig. 32.

As a rule damp-proof courses should be 6 in. or more above the level of the external ground, but, where possible, under the wall plate carrying the joints for the floor.

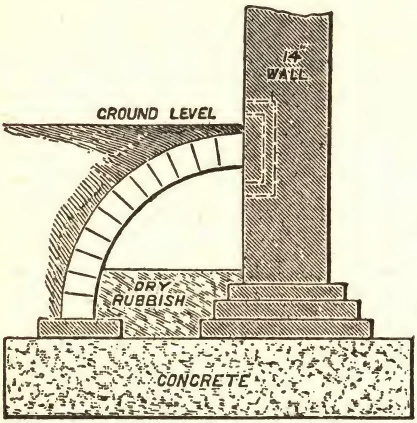


Fig. 33.

In buildings finished with a parapet wall, a damp-proof course should be inserted just above the flashing of the gutter, so as to prevent the wet which falls upon the top of the parapet from soaking down into the woodwork of the roof and into the walls below.

In some localities damp-proof courses are formed with slates set in cement; these are rather liable to crack, and thin impervious stones are better. Sheet lead has been used for the same purpose, and is most efficacious, but very expensive.

Arches are frequently rendered all over the extrados

with asphalt or cement to prevent the penetration of wet, same as shown in Figs. 33 or 34. In addition to the precaution adopted to prevent damp out of the ground from rising in walls, it is necessary (especially when using inferior bricks or porous stone) to prevent moisture falling upon the outer face from penetrating to the interior of the wall.

The wet may be kept out of the interior of the wall by rendering the exterior surface with cement, covering it with slates fixed on battens or with glazed tiles set in cement; glazed or enameled facing brick answer the same purpose.

Sometimes vertical damp courses are used as shown in Figs 34 and 35, particularly when the ground outside is higher than the wall plate inside, to prevent the damp penetrating through the wall. It will be seen that the damp course is bedded in the wall directly under the wall plate; this prevents the damp rising and destroying the wood. The vertical damp course acts in a similar manner in excluding the damp through the side of the wall; the joints of brickwork should be raked out to receive this damp

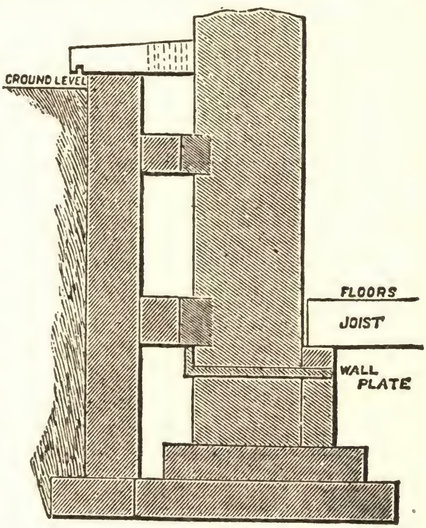


Fig. 34.

course Fig. 35 shows a good method of keeping damp out of the main walls. When the ground level is higher than floor level it will be seen that a 4½-in. wall is carried up to the ground level and covered on top with a stone coping fitted with an iron ventilating grating. By this method, as the damp penetrates through the 4½-in. outer wall, it rises and passes through the grating and into the open air. This wall is carried about 4½ in. from the face of main wall, and bonded into main wall as shown. Where the bonds enter, the main wall is tarred to prevent any damp entering.

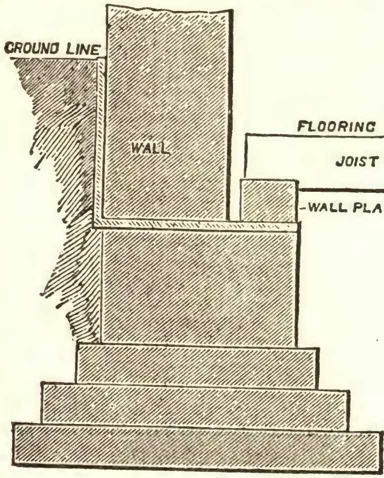


Fig. 35.

Another method of preventing damp from getting into a wall is to adopt what is known as the "dry area method," which is simply the building of a dwarf wall all around the building and leaving a space of two or more feet between the dwarf wall and the walls of the building as shown in Fig. 36. It will be seen by sketch that the ground is excavated to a width of 2 ft. from main walls and the dwarf wall built as shown to keep the water away: This area is necessary in damp situations, as any moisture or wet is carried away by a drain that is laid under the area, thus keeping the

main structure dry. The dwarf wall is finished with a brick-on-edge coping built in cement. The floor of area is usually covered with cement concrete paving to prevent the water soaking in. Fig. 33 shows an enclosed dry area formed by means of the arch; this area is drained as in Fig. 34, and the moisture is carried through the flue, as shown by dotted lines, into the open air. This flue is lined either by neat cement or by asphalt to prevent the moisture penetrating into the wall. Hollow or cavity walls should be used for external work in damp situations exposed to driving rains. Such walls are of brick or stone, with a cavity of 2 or 2½ in. The external wall should be 4½ in., the thicker portion being inside; false headers being used in the outer wall.

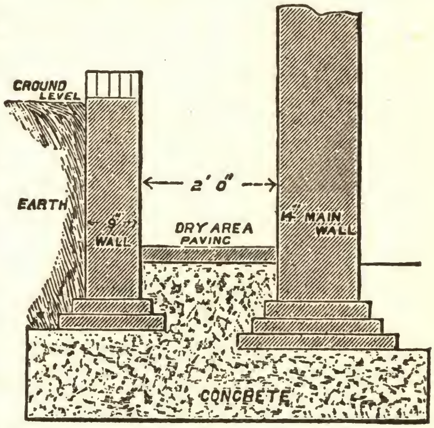


Fig. 36.

The thick wall inside will carry the doors and roofs, the woodwork being kept clear of the outer portion, which is liable to be damp.

The cavities should be ventilated by air-bricks in the external portion at top and bottom. Care must be taken that no mortar or other drippings get into them; movable boards or hay bands should be used.

The wall ties, generally of cast or wrought iron, galvanized or well tarred and sanded, should be employed

to tie the two walls together; or, better still, a tie or bonding brick, which is made for this purpose, may be used as shown in Figs. 37 and 38. Walls constructed after this method not only exclude the damp, but the layer of air they contain, being a non-conductor of heat, tends to keep the building warm. Such walls are formed in two separate portions, stand-

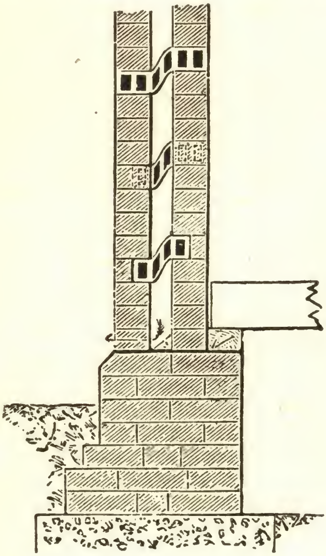


Fig. 37.

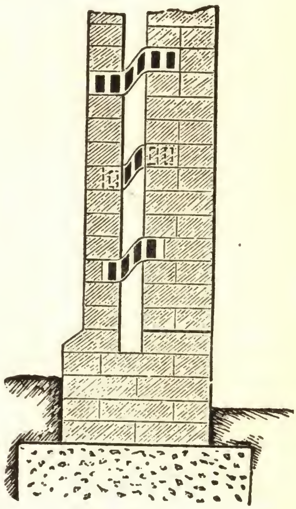


Fig. 38.

ing vertically parallel to one another, and divided by a space of about 2 to 3 in.

There are several ways of arranging the thickness of the portions of the wall, and the consequent position of the air space.

In some cases the two portions are of equal thickness, the air space being in the center, as at Fig. 37.

Very trequently one of the portions is only 4½ in. thick, built in brickwork in stretching bond; the other is of such thickness as may be necessary to give the whole stability, as in Fig. 38.

In such a case the thin 4½-in. portion is sometimes placed on the outside, and sometimes on the inner side of the wall.

In some cases, such for instance as when the wall has a stone face, the 4½-in. portion is necessarily on the inside, but this arrangement has many disadvantages.

In the first place, the bulk of the wall is still exposed to damp, and the moisture soaks in to within 7 or 8 in. of the interior of the building.

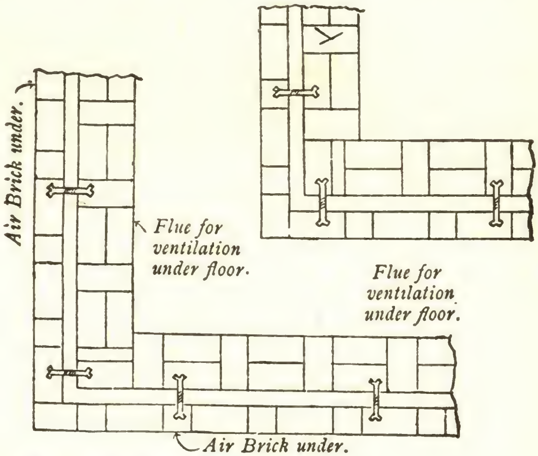
Again, if the wall has to carry a roof, expense is caused, as the span should be increased so as to bring the wall plates on to the outer or substantial part of the wall, clear of the 4½-in. lining.

This may be avoided by bridging over the air space, so as to make the wall solid at the top, which, however, renders it liable to damp in that part.

On the other hand, if the 4½-in. portion is placed outside, the damp is at once intercepted by the air space, kept out of the greater portion of the wall, and at a considerable distance from the interior of the building, and the thicker wall then carries the joists, also the whole weight of the roof.

The following illustrations, Figs. 39, 40, 41, 42, 43 and 44, show how a hollow wall should be constructed in order to have it substantial and effective. Fig. 39 shows how the angles should be bonded to secure good substantial work, also the position of the air-bricks to secure good ventilation. Fig. 40 shows how to bond the work around fireplace openings, flues and other

similar work. In Fig. 41, sections of a window and doorway are shown, also an elevation of brickwork with door and doorway in which are shown the positions of the metal ties marked by the little crosses. Fig. 42 shows a plan of the doorway bonded with ties. The elevation of wall shown in Fig. 43 illustrates the positions of the ties, also of the air-brick. In Fig. 44 the manner of finishing the top of the wall to take in



Plans of Bonding at Angles.

Fig. 39.

the wall plate and rafters is shown quite clearly, also the position of air-brick. In hollow walls care should be taken that the iron ties do not tip inwards, as water will in such case traverse even the double twist usually employed. The better shape has a V drip in the middle. To prevent the wet which may enter the air space dripping on the window or door frame, a piece of sheet lead is built in on the inner side of the 4½-in. exterior

wall, 1½ in. turned up and carried about 2 in. farther than the ends of the lintel.

There is another method sometimes resorted to because of its cheapness, and which, in some cases, proves quite effective where the ground is dry or composed of sand or gravel, and that is to lay common field tiles or weeping tiles all around the walls both inside and outside and connect them by drain tiles to the sewage system or to some low spot, where the drainage will be effective.

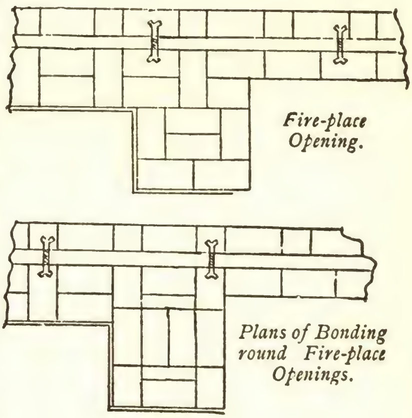


Fig. 40.

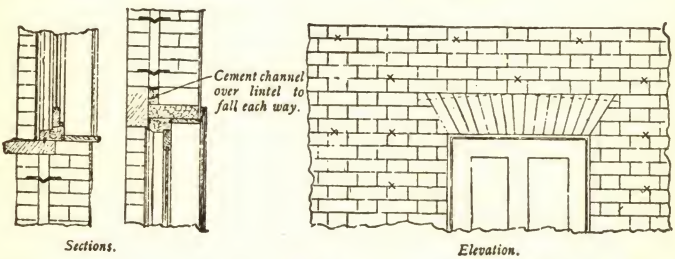


Fig. 41.

These weeping tiles should be on a level with the footings of the building and even lower when possible, to get a good fall so that the water will drain off readily.

It will be understood that the dampness of walls is usually owing directly to the absorbent qualities of the

materials of which they are composed and hence houses built of inferior bricks, which are always absorbent to a considerable extent, cannot be expected to be dry, and especially if they are in isolated positions, where the walls are exposed to the full blast of the weather. Even where good materials are employed, the same effects may be noticed in exposed buildings.

The best construction for a brick building in such positions is the employment of the hollow walls, as shown in the foregoing, which should be carried up throughout the whole of the structure. Their efficiency depends, as in the case of the area walls, upon

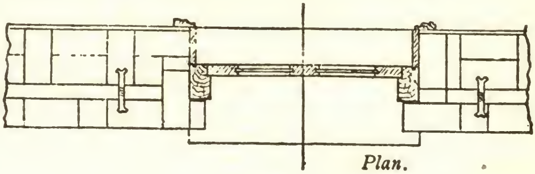
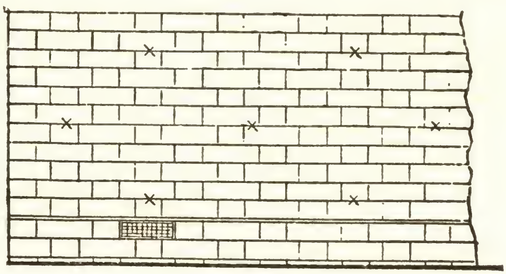


Fig. 42.

forming a cavity. A damp-proof course should also be provided, and may with advantage be made on the level of the cavity gutter, so as to answer for the two purposes. The few courses of bricks between the damp course and the footings may be built solid, the bricks being cut to form the necessary width. Various ties for connecting the casings are in the market, two of which are represented in the illustrations. That formed of brick is moulded so as to rise a course front to back to prevent the water from creeping along it, and the iron tie is provided with a middle indentation for the same purpose.

Properly constructed, these cavity walls are quite

effectual in rendering a building dry. They should always be employed for buildings standing by themselves. Strips of lead, tin, zinc or other metal must be placed over all door and window openings, being bent so as to throw any water falling upon them into the gutter below. Cavity walls cost very little more than solid ones. The quantity of bricks used in the construction is almost the same, the only extra materials being the ties and the guttering. Besides keeping the building dry, hollow walls have the advantage of rendering the interior of the house less affected by



Elevation.

Fig. 43.

changes in the temperature, rendering it cooler in the summer and warmer in the winter, a considerable advantage in a variable climate like this. The hollow space, moreover, lends itself very readily for the purposes of ventilation.

Dampness will sometimes be found to arise from the soil below the floor, and in building upon such soils the whole site should be covered in, beneath the lowest floor, with dry earth, or, better still, with a thin layer of concrete, which will prevent the damp rising from that source.

Referring now to the cure of damp buildings, it will nearly always be found to be at the best a troublesome matter. Sometimes the building will have been erected without a damp course, and the insertion of one by underpinning all around the building will, in such cases, generally effect a cure; or it may penetrate through the walls, either in the case of a cellar wall, from the earth resting against it, or from the rain beating through in the stories above. In the first case it may be removed by digging away the soil around the building and erecting a dry area wall, such as that before referred to, but as this is always quite an expensive way a simpler method may be tried. See that the earth around the building is properly graded, construct small air shafts at frequent intervals, inserting air-bricks above the ground line so as to place the space beneath the floor in direct communication with the outer air. This may be sufficient of itself, but if the wall is plastered and still shows signs of dampness, proceed as follows:

Hack off all the plaster from floor to ceiling. Place a stove in the middle of the room and keep up a large fire, night and day, until the walls feel quite dry to the hand. Then render the walls in plaster composed of nearly neat Portland cement.

Many obstinate cases have been cured in this manner. Re-rendering the plaster is expensive, and various paints and washes are in the market for application to the face of the plaster to keep out the damp. Some of them are effective, but the success of all depends upon the very simple precaution of stripping the whole of the paper from the walls and getting them dry before applying the wash or paint. In some cases the dampness will be found to rise some 2 ft. only from

the ground, and a cure has been attempted by painting the wall or applying lead foil beneath the paper to that height; but the method is useless, for the damp will only rise and show itself above the line of foil or paint.

In outside walls dampness will sometimes show itself in small patches here and there, and sometimes in quite large patches. The small patches probably arise from a few bricks of inferior quality which have inadvertently been built in the wall, and a cure can generally be brought about by covering the space on the inside of the wall beneath the paper with lead foil, using it to cover a space about 6 in. beyond the actual space of dampness. Where large spaces on the wall show damp, it may arise from defective gutters, from bad bricks, want of pointing, or other causes. Remove the cause, if possible, and if that cannot be done, the following remedy will prove of use. Melt 3 lbs. of strong soap in 4 gal. of water, and carefully apply to the wall, so as not to produce a lather. Mix ½ lb. of alum with 4 gal. of water, allow it to stand for 24 hrs. (by which time the soap will be in a condition to receive it), and carefully apply as before.

The following is said to be quite effective in keeping out damp, when properly applied to outside walls: Soft paraffin wax, 2 lbs.; shellac, ½ lb.; powdered resin, ½ lb.; benzoline spirit, 2 qts.; dissolve these by gentle heat in a water bath, then add 1 gal. of benzoline spirits and apply warm. The mixture is very inflammable, and must be kept away from the fire. We may mention here another method of making brickwork impervious to water, known as Sylvester's process, which was used with success on the Croton reservoir, Central Park, New York. It consists in the

successive application to the walls of two washes, one composed of Castile soap and water, and the other of alum and water. The proportions are ¾ lb. of soap to 1 gal. of water, and ½ lb. of alum to 4 gal. of water. The walls should be quite dry and clean, and the temperature of air not below 50 degrees Fahr. The soap wash is laid on first with a flat brush and at a boiling heat. After 24 hrs. the wash becomes dry and hard, and the alum wash is applied at a temperature of 60 to 70 degrees Fahr. This is allowed to remain 24 hrs., when the operation is repeated until the wall has become impervious to water. The number of applications required will depend on the water pressure to which the wall is subjected.

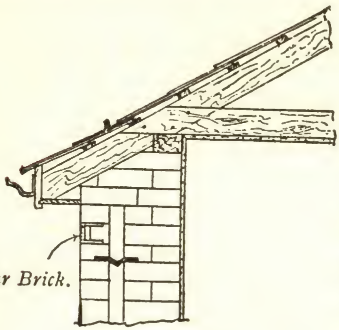


Fig. 44.

In the Croton reservoir cases, four coatings were found to render the reservoir free from leakage under 40 ft. head. This is similar to the recipe given in another paragraph. Resin has been used also as a protection against moisture. Five parts of turpentine, heated and stirred in ten parts of pulverized common glue, and one part of finely-sifted sawdust are then applied to the wall, which should be cleansed and heated by means of a lamp, so that the composition may run into every crack and joint. Very often a cement lining is of no use to make a tank water-tight, especially where the bricks and joints are of an inferior description, and the aim should be to get a composition which, when heated,

enters the pores of the brickwork and renders them impervious.

The top of a wall also may be as likely to admit dampness as the bottom or sides, if it is not properly protected by the roof or by proper copings; as the rain, sleet and snow are liable to soak down into the body of the brickwork and cause damp and decay.

Copings may be of a variety of shapes and materials, stone, copper or other sheet metal, terra-cotta tiles, brick or cements. If bricks are employed, good Portland cement mortar should be plastered over it, cover-

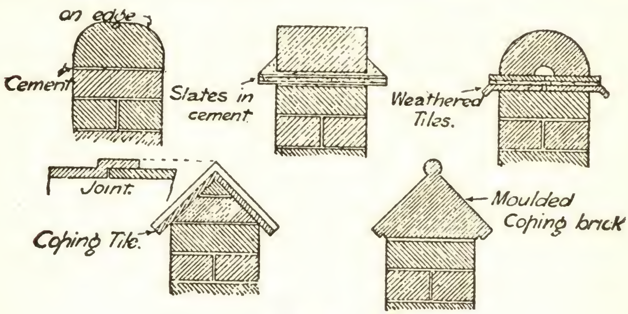


Fig. 45.

ing it at least an inch deep. A number of copings are shown in Fig. 45. The first illustration shows a wall covered with a half-round pressed brick laid in cement mortar. The other illustrations show for themselves.

There will often occur cases where it will be expedient to support loads by the method of brick corbeling, which consists of one or more courses projecting the required distance from the wall.

There are two points that have to be considered in corbeling. The first is, that as every projecting brick is acting as a cantilever the end of the brick should be

tailed into the wall as far as possible. To obtain this, as many headers as are available are used. Secondly, the projection of every course over the one below should not exceed 2¼ in.; but it is better if it is only 1⅛ in. Corbeling renders the walls less stable by bringing the center of gravity of the mass nearer the internal edge of the wall. Figs. 46 and 47 give two examples.

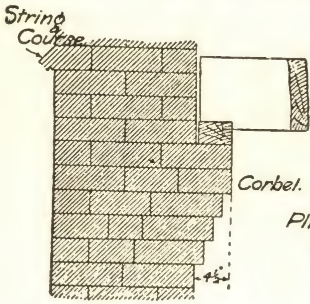


Fig. 46.

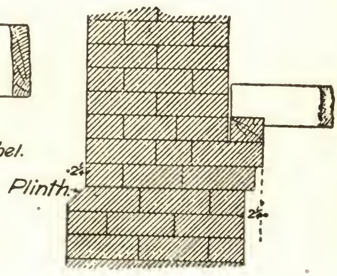
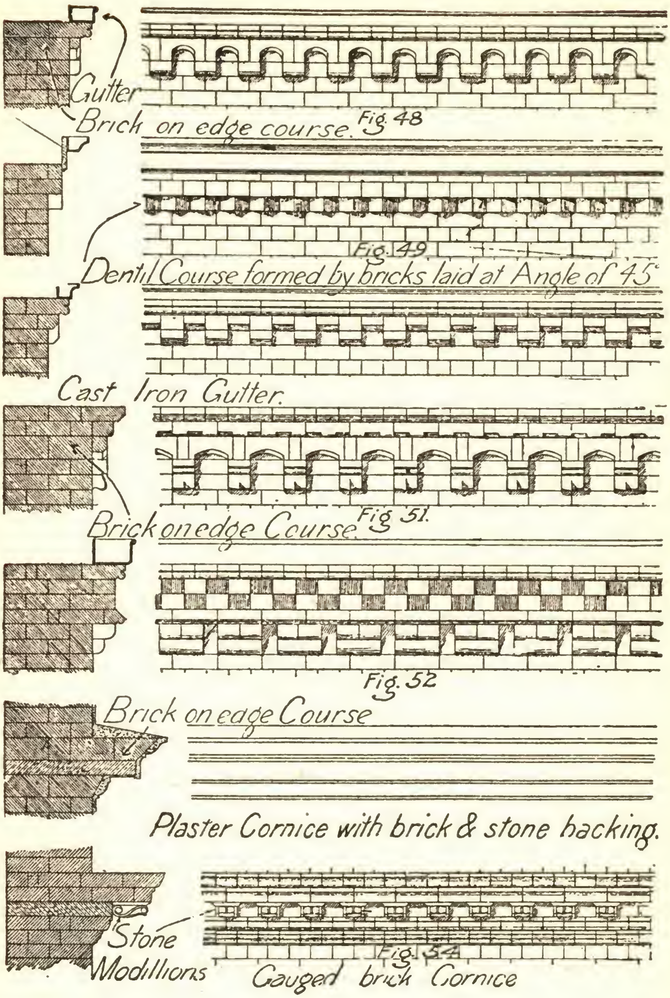


Fig. 47.

BRICK CORNICES

Brick cornices are carried out on the principles of corbeling, the length of bricks being 9 in. No cornice made entirely of bricks should project more than that amount. This being accepted, bricks are more suitable for the large projecting cornices of buildings treated in the classic styles. Wherever bricks are employed in the latter styles, if the cornice has modillions, the latter are usually of stone of a color resembling the bricks and well tailed into the wall, thus forming a support for the crowning courses, as shown in Fig. 48. Fig. 49 shows the brick backing for a plastered cornice; the large projection is also here obtained by the use of stone. Bricks are more suitable for cornices of buildings of the Gothic styles,


Gutter
Brick on edge course. Fig. 48
Fig. 49
Dentil Course formed by bricks laid at Angle of 45°
Cast Iron Gutter.
Brick on edge Course. Fig. 51.
Fig. 52
Brick on edge Course
Plaster Cornice with brick & stone backing.
Stone Modillions
Fig. 54
Gauged brick Cornice

which usually resolve themselves into a moulded band supported by a corbel table, as shown in Figs. 50 to 54. In either variety there is no detriment in placing the bricks on edge wherever the dimensions of the members or disposition of the arts render that arrangement necessary.

Another style of cornice, in which moulded bricks are used, is shown in Figs. 55 and 56. In setting this out, convenient lengths should be taken, e.g., from

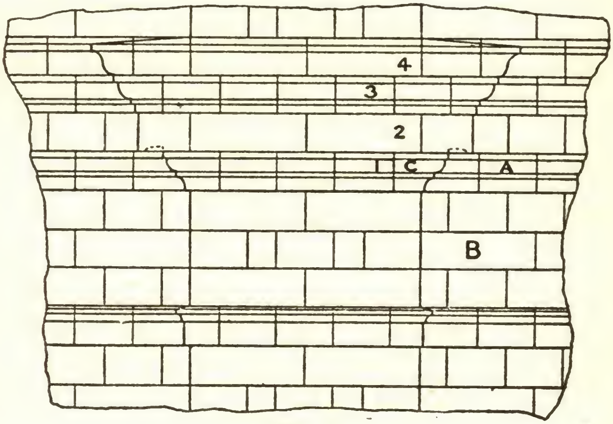


Fig. 55.

and including pilaster and pilaster, and the whole, or in the case of a long length, the half, or even quarter, should be laid out upon plan, breaking round projecting keys, etc., the setting out pricked over for headers and stretchers, or, if the projection be too great, then for headers only, so as to get an exact number without broken bond. It may occur that the headers and stretchers are slightly over or under 4½ and 9 in.; but, whatever the size, a gauge is cut to it, and the headers and stretchers reduced to the gauge. The bricks

should be joggled, and the work properly run in with Portland cement. All internal miters, stopped returns, etc., in cornices should be solid. Some brick cutters make cut miters, putting them together dry, as being an easier method; but this is not correct work.

It will be noticed in Fig. 55 that the cornice is continued round, and forms a cap to the pilaster; the principal perpends in the plain work of this and of the general face work being continued through the cornice as far as possible. The breaking out of the returns

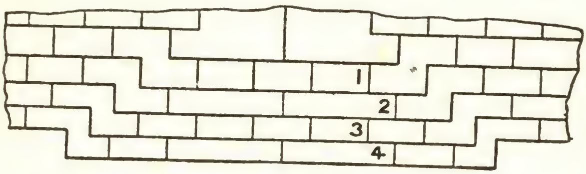


Fig. 56.

round the pilaster and the bonding between the latter and the straight run of cornice is made out where necessary in between. Thus taking course 1 of the cornice in elevation, Fig. 55, the brick A pairs with the plain brick B, which goes home to the pilaster. If A did the same, then a joint would occur immediately over the angle of the pilaster, and the return would appear as if it were merely stuck on, which would be unsightly; hence, to remove the joint from this point, A becomes a bat header, and a solid return is obtained in the three-quarter bat C, which, on account of projection, as will be seen upon plan, is made out by a brick shellacked to the back of it. As already stated, it is sometimes necessary for headers only to be used in cornices. This applies with greater force to the top course, where they are frequently

beveled to form a weathering. The bonding of the courses 1, 2, 3 and 4 upon elevation agrees with those marked 1, 2, 3 and 4 upon plan. (See Fig. 56.)

In making plain pilasters and cutting and setting them out, but little more skill is required than that of gauging bricks for a Gothic arch, unless they be fluted or seeded, or both; then a pair of moulds cut to the plan of the pilaster should be used; the brick being worked in the box face upwards, the back of the brick on the bottom of the box being roughly squared. The difficulty lies in setting out the proper bonding of the base and cap. The full-size plan and elevation of each should be worked in conjunction with a few courses of the plain work; the bond accurately set out, and the work cut according

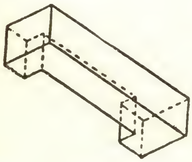


Fig. 57.

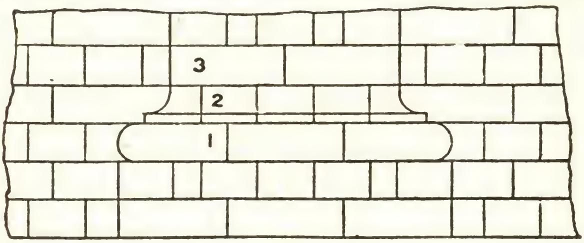


Fig. 58.

to it (see Figs. 58 and 59, which represent the elevation and plan respectively of the base). Here it will be noticed that the bonding of the plain work of the pilaster and also the general face work is kept as far as possible, courses 1, 2, 3 of the elevation agreeing with 1, 2, 3 of the plan. The cap of the pilaster is taken in conjunction with cornices.

Pilasters vary in shape upon plan, and the correct

bonding must be dealt with as the cases occur; but an instance is given in Figs. 60 and 61 of a half-octagonal pilaster, and in Figs. 62 and 63 of a half-hexagonal.

It frequently happens that the bricklayer has to panel a wall under windows, in gables and other similar places, and in order that the workman may be

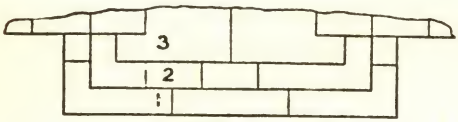


Fig. 59.

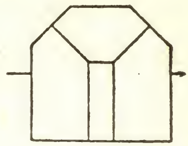


Fig. 60.

prepared for such work the following has been selected which gives a few instructions on the subject, and which will be found simple and easy to follow:

In setting out panels, the height is usually kept in courses with the general work; but the width is not always the multiple of a 9-in. stretcher, and needs consideration. Set up a quarter of the panel, what-

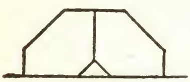


Fig. 61.

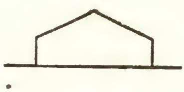


Fig. 62.

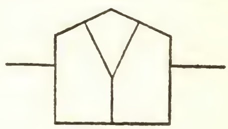


Fig. 63.

ever the width, including the moulding, and prick over for headers and stretchers. Let Fig. 64 be a quarter of a panel, measuring 4 ft. in width. Had the width been 3 ft. 9 in., it is very clear that five 9-in. stretchers would exactly fill it; but, as it is 3 in. over this, divide the 3 in. equally among the five stretchers, making them slightly over 9 in., and the headers and closers in proportion. The joints will be arranged as in Fig. 64; the mould for the side stretchers, e.g.,

A B, etc., will be as in Fig. 65, one side of the brick being roughly squared and placed on the bed of the box; thus the brick will be worked on edge with the moulding upwards; the moulds for the top and bottom horizontal moulding being as in Fig. 66, and

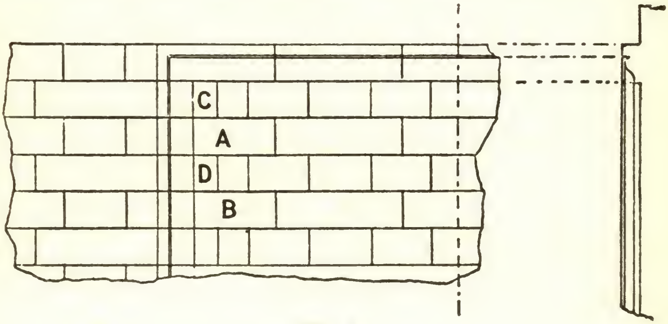


Fig. 64.

worked with the roughly squared bed of the brick on the bottom of the box, the moulding again being upwards. The side headers C D, etc., will require another pair of moulds (Fig. 67), the brick being placed in the box on edge and moulded on the end.

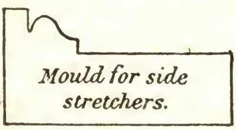


Fig. 65.

Fig. 66.

All angles should be cut in the solid brick, with no mortar joint.

A projecting key is sometimes adopted in an arch as an ornamental feature, when some few of the center bricks, including the key-brick and those adjacent, are made to stand out from the general face of the arch;

sometimes being also moulded (Fig. 68). Whatever size the block may be at the top, it is divided into odd courses; thus 8 in., 9¼ in., etc., would make three courses, 14 in. five courses, etc., the course being cut to the same template as those for the rest of the arch, though, if necessary, to a different cutting mark. If the projecting key is also to be moulded on the face, as Fig. 68, the bricks are first cut to the template, the depth and thickness being properly arranged and bonded (Fig. 68 and 69, which show one course in definite and the other in dotted lines), then set, or "blocked" as it is practically known, together with white lead and shellac, and afterwards cut in the box, face upwards, in the same way as ordinary mouldings.

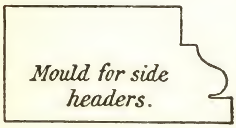


Fig. 67.

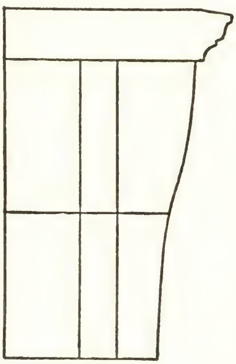


Fig. 68.

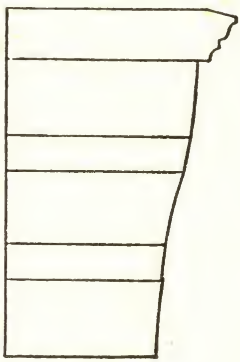


Fig. 69.

There are many other difficult and interesting details in ornamental brickwork, which it is hoped will be treated upon in some future work.

BONDING

The question of "bond" is one of the most important in brickwork, yet few bricklayers give much attention to this department of this work. They generally follow certain rules customary in the locality in which they reside, or methods they learned during their apprenticeship.

Bond (that is, to bind) is the name given to any arrangement of bricks in which no vertical joint of one course is exactly over the one in the next course above or below it, and having the greatest possible amount of lap.

Bond in brickwork is the method of arranging each brick so that it laps over the bricks with which it is in contact above and below a distance equal to one-quarter of the length of the brick. To ensure good bond the following rules should be rigidly adhered to: First, the arrangement of the bricks must be uniform, and as few bats as possible be employed; second, a closer to be inserted after the quoin header in any course; third, the vertical joints in every other course to be perpendicularly in line on the internal as well as the external face; fourth, stretchers are only to be used on the faces of the wall, the interior to consist of headers only, except in footings and corbels; fifth, the dimensions of bricks should be such that, when bedded, the length should equal twice the width plus a mortar joint.

Hindrances to good bond often occur when facing or pressed bricks used are costly or of different lengths and widths to the body of the wall; in 9-in. walls, where it is necessary to have two fair faces, very frequently facing both on the outside and inside.

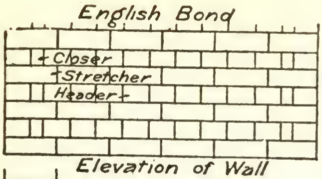


Fig. 69½

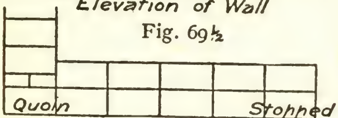


Fig. 70.

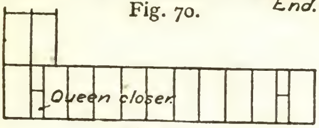


Fig. 71.

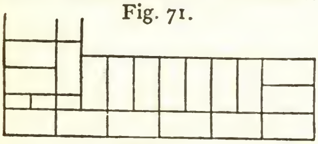


Fig. 72.

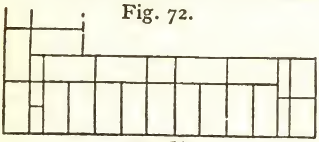


Fig. 73.

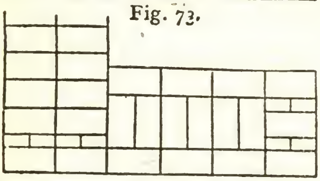


Fig. 74.

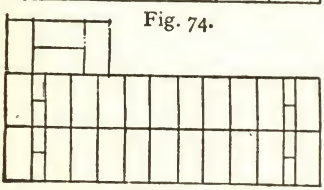


Fig. 75.

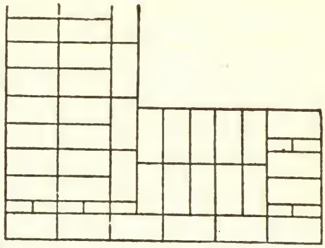


Fig. 76.

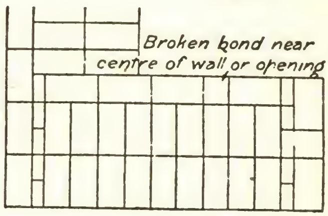


Fig. 77.

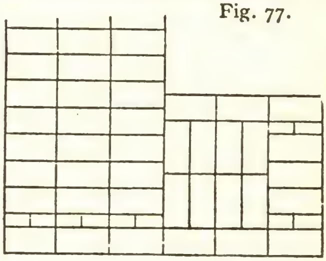


Fig 78.

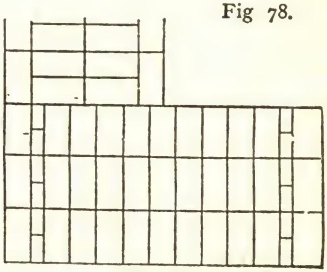


Fig. 79.

Figs. 69–79. Examples of English Bond.

There are several kinds of bond used in brickwork, among which we may name: first, English; second, double Flemish; third, single Flemish; fourth, English cross; fifth, Dutch; sixth, stretching or chimney; seventh, heading bond; eighth, country or garden-wall bond; ninth, raking bonds; tenth, hoop-iron bond. When the bond is arranged as shown in elevation and plan Figs. 69½ to 79, it is known as English bond, and sometimes old English bond. It consists of one course of headers and one course of stretchers alternately. In this bond, bricks are laid as stretchers only on the boundaries, of course, thus showing on the face of the wall, and no attempt should be made to break the joints in a course running through from back to front of a wall. That course which consists of stretchers on the face is known as a stretching course, and all in course above or below it would be headers with the exception of the closer brick, which is always placed next to the quoin header to complete the bond, and these courses would be called heading courses.

It may be noticed that in walls, the thickness of which is a multiple of a whole brick, the same course will show either:

(*a*) Stretchers in front elevation and stretchers in back elevation.

(*b*) Headers in front elevation and headers in back elevation; but in walls in which the thickness is an odd number of half bricks the same course will show either:

(*a*) Stretcher in front elevation and header in back elevation.

(*b*) Header in front elevation and stretcher in back elevation.

In setting out the plan of a course to any width,

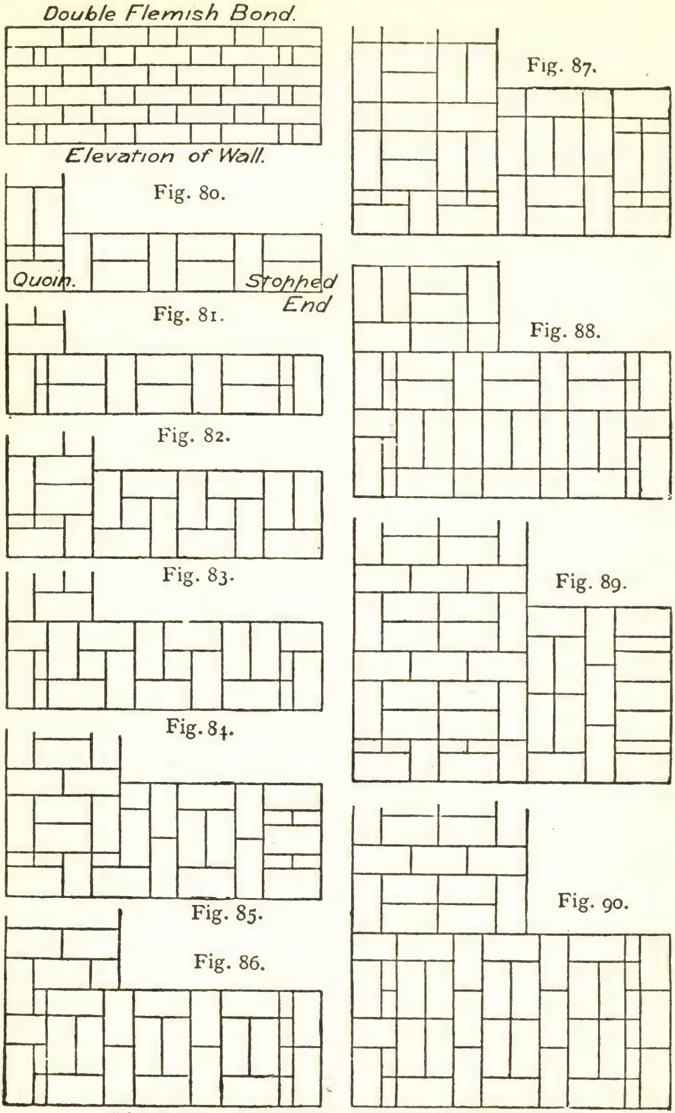


Fig. 80–90. Examples of Double Flemish Bond.

draw the quoin or corner brick; then next to the face (which in front elevation shows headers) place closers to the required thickness of the wall, after which set out all the front headers, and if the thickness is a multiple of a whole brick, set out headers in rear; the intervening space, if any, is always filled in with headers.

Double Flemish bond has headers and stretchers alternately in the same course, both in front and back elevations, as shown in Figs. 80 to 90. It is weaker than English bond, owing to the greater number of bats and stretchers, but is considered by some to look better on the face. It is also economical, as it admits of a greater number of bats being used, so that any bricks broken in transit may be utilized. By using double Flemish bond for walls one brick in thickness, it is easier to obtain a fair face on both sides than with English bond.

Single Flemish bond consists in arranging the bricks as Flemish bond on the face, and English bond as backing. This is often done on the presumption that the strength of the English bond as well as the external appearance of the double Flemish is attained, but this is questionable. It is generally used where more expensive bricks are specified for facing. The thinnest wall where this method can be introduced is 1½ brick thick. Plans of alternate courses are given (Figs. 91 to 99). The front elevations are the same as in double Flemish bond.

English Cross Bond.—A class of English bond. Every other stretching course has a header placed next the quoin stretcher, and the heading course has closers placed in the usual manner (Fig. 100).

Dutch Bond.—In every alternate stretching course a

Fig. 91.

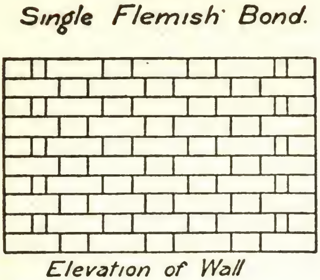


Fig. 92.

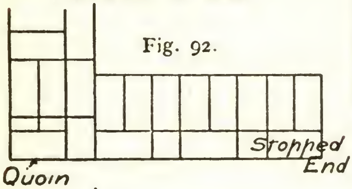


Fig. 93

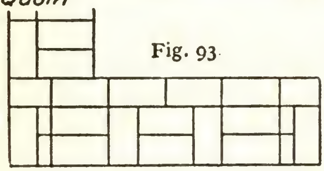


Fig. 94.

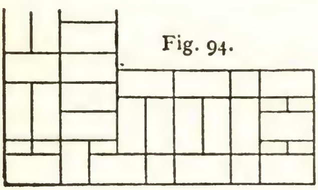


Fig. 95.

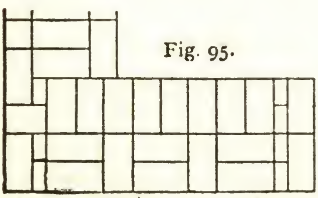


Fig. 96.

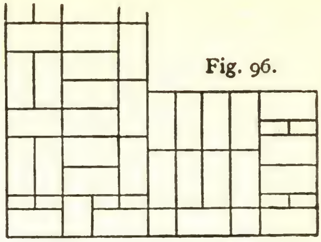


Fig. 97.

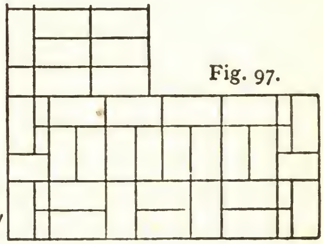


Fig. 98.

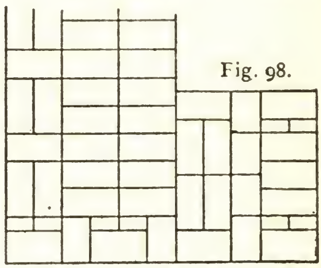
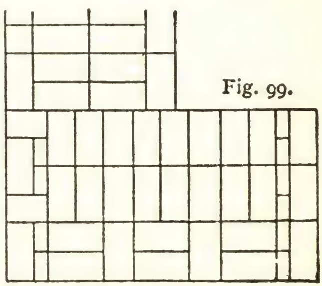


Fig. 99.



Figs. 91–99. Examples of Single Flemish Bond.

header is introduced as the second brick from the quoin; three-quarter bricks are used in the remaining stretching courses at the quoins, and the closers are dispensed with in the heading courses, as shown in Figs. 101 to 105; the longitudinal tie becomes much greater, and the appearance of the elevation is certainly superior to much of the inferior work one is accustomed to see as examples of the modern bricklayer's skill in bonding. Should there be a fracture, it is supposed to throw it more obliquely.

Stretching bond should be used only for walls half brick thick, as for partition walls. All bricks are laid as stretchers upon the face.

Garden or boundary-wall bond, country bond, Scotch bond, are the names given to walls built with three stretchers and one header in same course, constantly recurring, as shown in elevation, Fig. 106. This method is used for walls one brick thick that are seen on both sides, as it is easier to adjust the back face by decreasing the number of headers, the lengths of which usually vary.

Heading bond is used when circular corners have to be turned, as in Figs. 108 and 109. It is evident that stretchers, unless it be upon a large curve, would be too long for this purpose.

In walls built of material in which it is impossible to get a bond, two or three courses of brickwork are frequently introduced to act as a tie or bond; these are termed *lacing courses*. Again, in big arches, consisting of 4½-in. brick wings, lacing courses are sometimes used to give additional strength, as in Fig. 110.

Hoop-iron Bond.—An additional longitudinal tie termed "hoop-iron bond" is often inserted in walls, being usually pieces of hoop-iron 1 in. × $\frac{1}{16}$ in., one

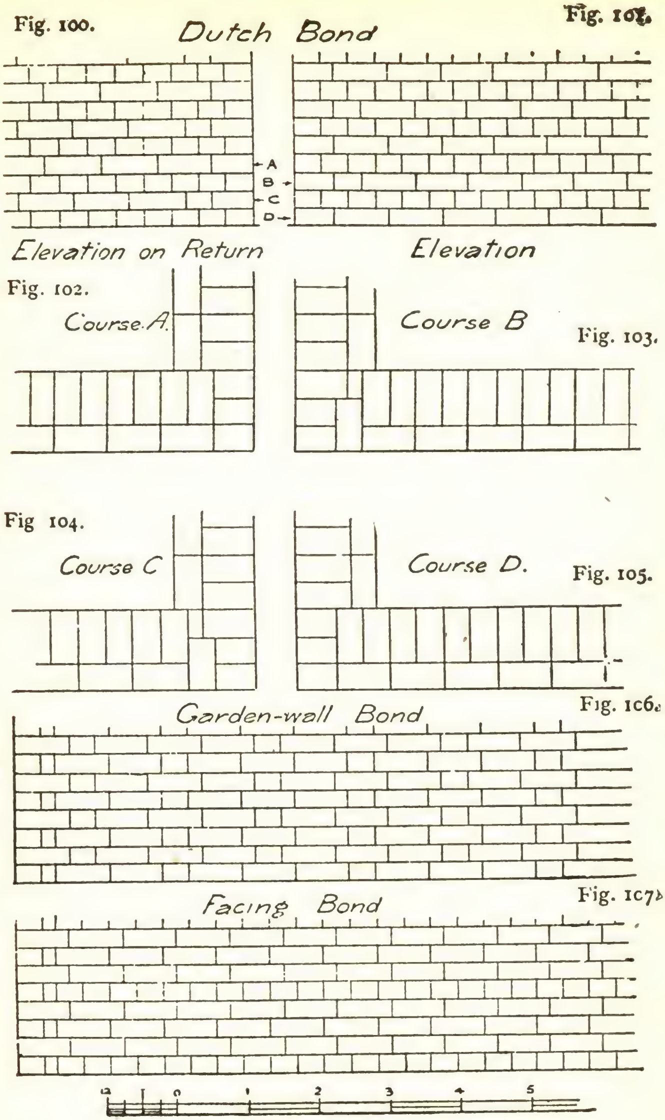


Fig. 100.
Dutch Bond
Fig. 101.
A
B
C
D
Elevation on Return
Elevation
Fig. 102.
Course A.
Course B
Fig. 103.
Fig 104.
Course C
Course D.
Fig. 105.
Garden-wall Bond
Fig. 106.
Facing Bond
Fig. 107.
0
1
2
3
4
5

Figs. 100–107.

row for every half brick in the thickness; should be carefully tarred and sanded or galvanized before using, to prevent oxidation. It is hooked at all angles and junctions. If bedded in two courses in cement, additional strength is gained; pieces of hoop-iron may be used with advantage where the bond at any part of the wall is defective.

Raking Bonds.—Walls as they increase in thickness increase in transverse strength, but become proportionally weaker in a longitudinal direction, owing to the fact that stretchers are not placed in the interior of a wall.

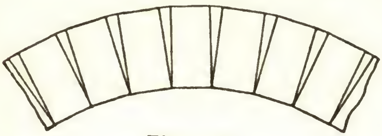


Fig. 108.

This defect is remedied by using raking courses at regular intervals of from four to eight courses in the height of a wall. The joints of bricks laid in this position cannot coincide with the joints of the ordinary course directly above or below, the inclination of the

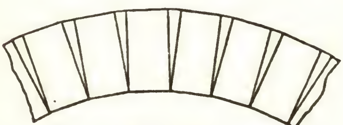


Fig. 109.

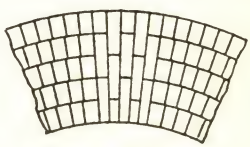


Fig. 110.

face usually being determined by making the extremities of the diagonal of two, three or more bricks coincide with the backs of the facing bricks. It is not advisable to use one raking course directly above another, as there is always a weakness with the face bricks at the junction of the raking.

Raking bonds are always placed in the stretching

courses in walls of an even number of half bricks in thickness, in order that their influence may extend over a greater area than would be the case if they were placed in the heading courses.

The alternate courses of raking bonds should be laid in different directions, in order to make the tie as perfect as possible.

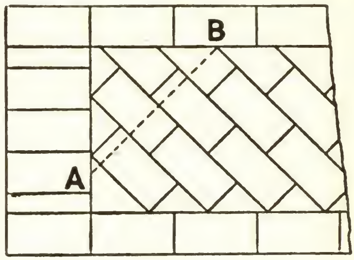


Fig. 111.

There are two varieties of raking bonds, viz., diagonal and herring-bone.

Diagonal Bond.—This is used in the thinner walls, i. e., between two and four bricks in thickness. The operation is as follows: The face bricks are laid; one or more bricks (in the latter case placed end to end) are bedded between the face bricks, so that the opposite corners touch the latter; this determines the angle that the bricks should be laid, the triangular spaces at the ends of the bricks being filled up with small pieces of brick cut to shape, as shown in Fig. 111.

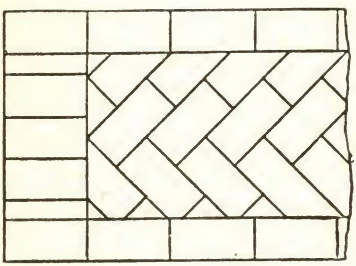


Fig. 112.

Herring-Bone Bond.—The bricks in this method are laid at an angle of 45 degrees, commencing at the center line and working towards the face bricks. Herring-bone bond is used for walls four bricks and upwards in thickness. Fig. 112 shows this method.

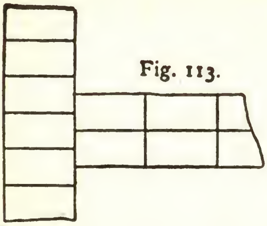


Fig. 113.

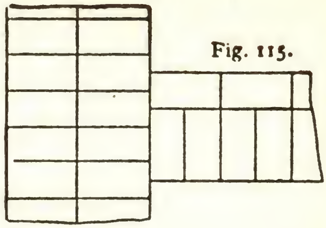


Fig. 115.

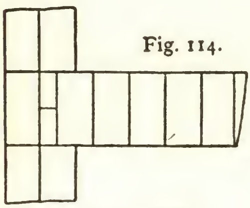


Fig. 114.

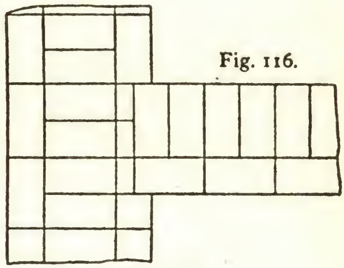


Fig. 116.

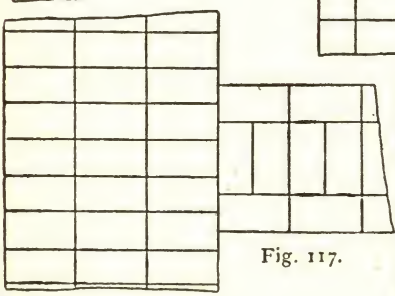


Fig. 117.

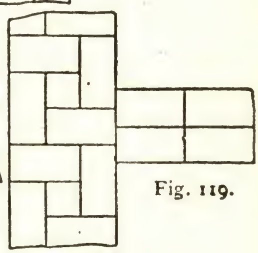


Fig. 119.

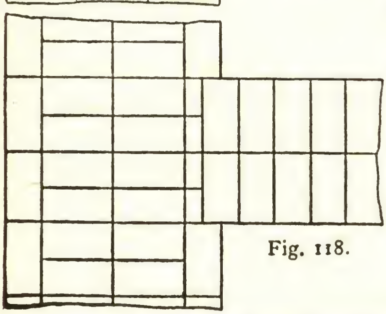


Fig. 118.

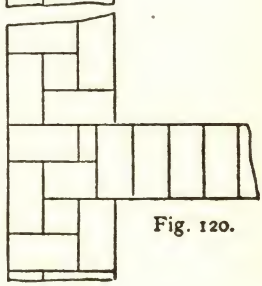


Fig. 120.

Figs. 113–120 Junctions of Cross Walls.

Diagonal and herring-bone patterns are often used to form ornamental panels in the face of walls, and also in floors paved with bricks.

Junction of Cross Walls.—The bond is obtained in cross or party walls abutting against main walls by placing a closer 4½ in. from the face in every alternate course in the main wall, thus leaving a space 2¼ in. deep and of a length equal to the thickness of the cross wall for the reception of the 1¼-in. projection in every other course of the cross wall, as shown in Figs. 113 to 118.

Figs. 119 and 120 illustrate the junction of one-and-a-half brick Flemish bond with one brick English bond.

Reveals.—The vertical sides of window or door openings between the face of wall and window or door frames. The horizontal distance between is the clear span of opening.

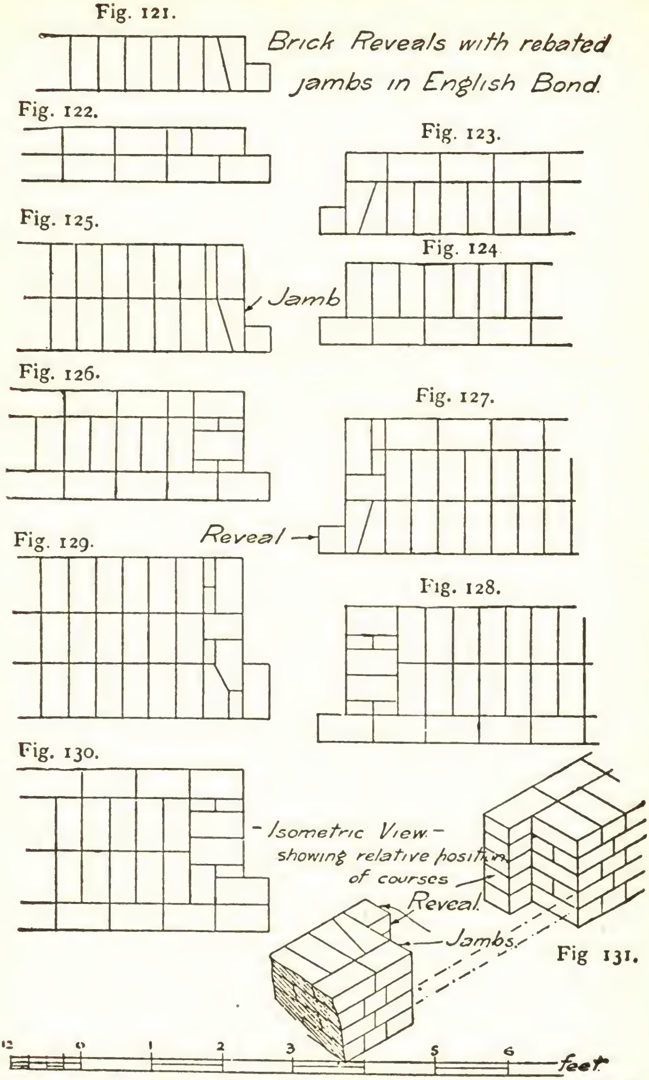
Jams are the vertical sides of an opening, and in rebated window or door openings there are the internal jambs and external jambs, the latter being known as the reveals.

Internal jambs are usually covered with plaster, or wood linings.

Figs 121 to 131 show brick reveals, with rebated jambs in English bond.

Splayed Jambs.—The internal jambs of windows occurring in thick walls are often splayed to obstruct as little light as possible. Figs. 132 to 142 show the method of bonding two alternate courses of a three-brick wall, built in single Flemish bond. In inferior work splayed jambs are often formed by simply constructing a number of square offsets.

Squint Quoins.—External angles other than a right angle in plan are called squint quoins. Such require



Figs. 121-131. Brick Reveals with rebated jambs in English Bond.

considerable care in the planning, as different angles require special modifications of the principles of bonding.

Two general rules should be kept in view, viz.: (1) no bird's mouth joint in plan should be employed, except on the face of the work in acute angular quoins, where it is at times absolutely necessary. They would be useful in the interior in some cases, but sufficient care is not usually taken in cutting the re-entering angle where the brick is not exposed to view, the latter generally becoming cracked or broken, as bricks do not lend themselves to be easily cut in this manner. (2) All small pieces should be avoided, the bricks being as nearly as possible whole, and only having sufficient cut off to adapt them to the plan. Closers are not always necessary in obtuse angles; better work is produced where they can be superseded. It is evident that the quoin stretcher can never show its full length on either face. Advantage should therefore be taken, if the angle is not too great, to show three-quarters of a brick at the quoin, as shown in Figs. 137 and 138, thus obviating the necessity of a closer to gain the proper 2¼-in. bond; but in acute angles, the quoin stretcher can always be obtained in its full length, as shown in Figs. 139 and 140.

Figs. 132 to 136 show the method of constructing squint piers, such as would be employed in the angles of bay windows.

Toothing.—The usual method of leaving a brick wall which is to be continued at some future time is to tooth it, which consists in leaving each header projecting 2¼ in. beyond the stretching courses above and below to allow the new work to be bonded to the old as shown in Fig. 144.

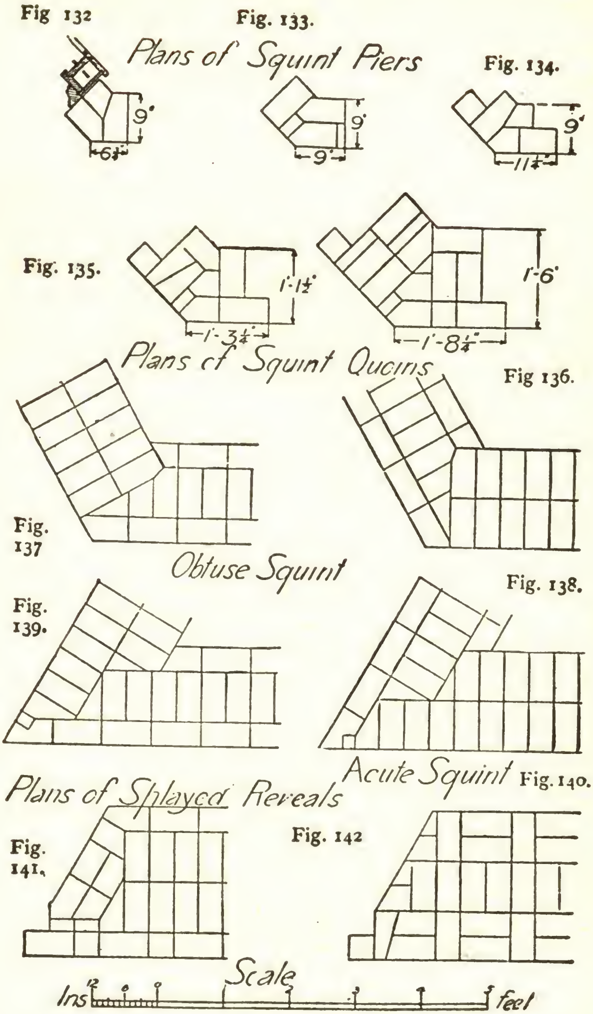


Fig 132
Fig. 133.
Plans of Squint Piers
Fig. 134.
9"
9"
9"
9"
11¼"
Fig. 135.
1'-1½"
1'-3¾"
1'-6"
1'-8¼"
Plans of Squint Quoins
Fig 136.
Fig. 137
Obtuse Squint
Fig. 138.
Fig. 139.
Acute Squint
Fig. 140.
Plans of Splayed Reveals
Fig. 141.
Fig. 142
Scale
Ins
feet

Figs. 132—142.

The usual practice in joining new cross walls to old main walls is to cut out a number of rectangular recesses in the main walls equal in width to the width of the cross wall, three courses in height, and half a brick in depth; a space of three courses being left between the sinkings (as shown in Fig. 143); the new cross wall is then bonded into the recesses with cement mortar to avoid any settlement. It is necessary that the sinking should not be less than 9 in. apart, as in the cutting the portion between is likely to become shaken and cracked.

Racking.—Racking is the term applied to the method of arranging the edge of a brick wall, part of which is unavoidably delayed while the remainder is carried up. The unfinished edge must not be built vertically or simply toothed, but should be set back 2¼ in. at each course, to reduce the possibility and the unsightliness of defects caused by any settlement that may take place in the most recently built portion of the wall.

Also where new walls are erected the usual method of procedure is to build what is technically termed a corner—that is, the angles or the extremities of the walls—to a height of two or three feet, the angle bricks being carefully plumbed on both faces. The base of the corner is extended along the wall, and is racked back as the work is carried up, as shown in Fig. 145. The intermediate portion of the wall is then built between the two corners, the bricks in the courses being kept level and straight by building their upper edges to a line strained between the two corners.

Leveling of Brickwork.—In bedding bricks, great care should be taken to keep all courses perfectly level. To do this, the footings and the starting course should be carefully leveled through, using a level at

Fig. 143.

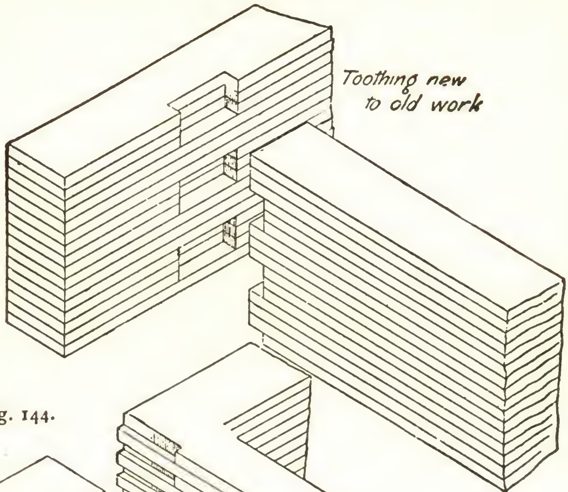


Fig. 144.

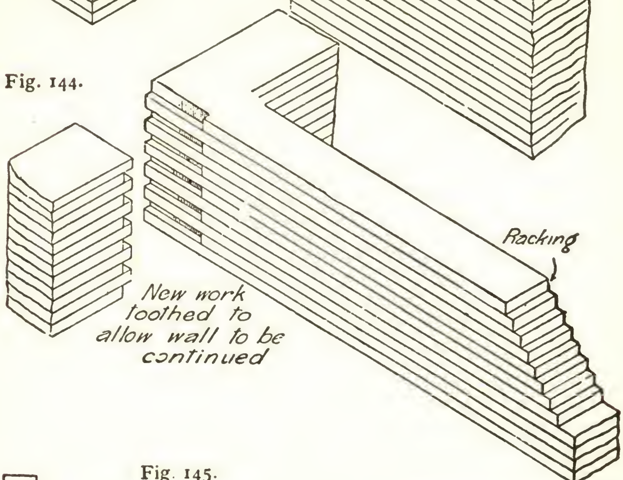
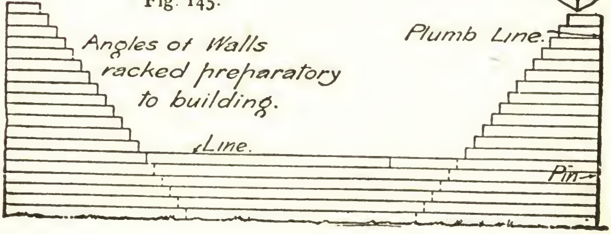


Fig. 145.



least 10 ft. in length, commencing at one end and leveling towards the other, and taking care to reverse the level each time at each forward step, and completing the length to be leveled in an even number of steps. A piece of slate or iron is left projecting from the lowest course, and from this all other courses at the corners can be leveled by using the gauged rod, which is usually about 10 ft. in length, with the courses marked on it. The work should then be again tested by the level, and the operation repeated.

Joints.—Bricks and stones are bedded with mortar for two purposes, viz., to cause the bricks to adhere to each other, and to distribute the pressure uniformly over the whole bed where the beds of the bricks or stones are irregular. Great care should be taken that both the bed and side joints are thoroughly flushed, or filled up with mortar. This is done in three ways: 1, by the trowel; 2, by larrying; 3, by grouting. The first method is that usually adopted in thin walls. The second, larrying, is largely adopted in thick walls. The face bricks are first laid; the mortar, in a semi-fluid condition, is then poured into the space between the face bricks; the bricks are then pushed rapidly horizontally for a short distance into their position; a certain amount of the mortar is thus displaced; this rises in the side joints, and completely fills all the interstices; should the mortar not rise to the top of the joints, the vacant spaces are filled up when the next course is larried. (3) Grouting is an operation used in brickwork, generally for gauged arches and similar work, where fine joints are required; it consists in mixing the mortar to a fluid condition, of about the consistency of cream, this being poured into the joints of the work after the latter has been placed in position.

Joints on Face.—The joints on the face of work are finished in a variety of ways, as shown in Figs. 146, A to L, to increase the effect, and to resist the weather; they may be finished as the work proceeds, or as the scaffold is taken down on the completion of the building; the former is the stronger and more durable, the latter is cleaner and has a better appearance, and is rendered necessary when the work has been built during frosty weather; where the latter method is employed, the joints should be raked out for at least ½ in. in depth as the work proceeds. The joints in new work should be clean, sharp and regular; but no fancy pointing is permissible. Fig. 146, A to L, shows the forms of joints applied to brickwork.

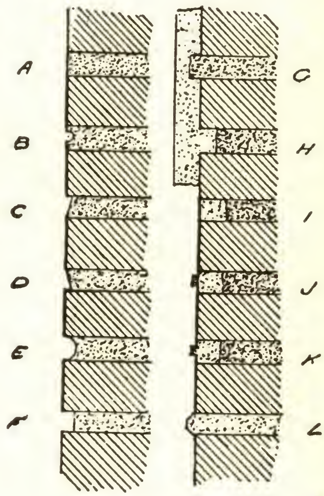


Fig. 146 *a* to *l*.

Flat or Flush Joints.—This is formed (as shown in Fig. 146, A) as the work proceeds by pressing with the trowel the wet mortar that protrudes beyond the face, flat and flush with the wall.

Flat Joint Jointed.—This is formed similarly to the above (as shown in Fig. 146, B), but has, in addition to the previous joint, a semicircular groove run along the center of each joint, with a jointing tool and straight-edge. This has the effect of making the mortar more dense.

Struck Joints.—This is formed by pressing with the trowel the mortar along the upper edge of the joint slightly below the surface, as shown in Fig. 146, C. This is a good joint, as the upper edge of the mortar is protected, and any water is thrown off with facility; its appearance is good, as it presents a sharp shadow at every horizontal joint, and forms the method of finishing new work; it is sometimes called a weather-struck joint. The mortar is often ignorantly struck back on the lower edge, as shown in Fig. 146, D, under the impression that the appearance is enhanced thereby, the idea being that a sharp line is presented on the upper edge of the bricks, but as no shadow is formed the effect is lost at a few feet above the eye; a ledge is formed on which the water lodges, which freezes in the winter, and rapidly destroys the upper edges of the bricks and the joint.

Keyed Joint, as shown in Fig. 146, E, is formed by drawing a jointing tool with a curved edge, the same width as the joint, along the latter; it has the effect of making the mortar dense at this part, and improves the appearance by making the joints distinct. It is not much used.

Keyed joints of the form shown in Figs. 146, G and H, are employed where the wall is to be rendered. In the first case, the mortar in the joints is left protruding; in the second, it is raked out.

Recessed Joint.—This is used to obtain a pleasing and deep shadow, but care must be taken that the bricks are hard and unlikely to be damaged by the weather. It is the joint employed in many of our best buildings. Fig. 146, F, gives this joint.

Pointing Old Works.—This operation consists in raking out the decayed mortar from the joints to a depth

of at least ¾ in. and in filling the same with cement. or some hard-setting mortar, as shown in Fig. 146, I. The joints may be finished in any of the methods stated, or by one of the two methods known as tuck and bastard tuck pointing, which are fancy forms adopted by bricklayers to increase the effect by forming sharply defined joints.

Tuck pointing, as shown in Fig. 146, J, consists in filling up the raked-out joints flush with a stopping of cement or some hard mortar. The joints in this condition generally appear very wide, owing to the edges of the bricks being ragged, this being due to the frost or to the clumsy method in which the joints have been raked. The whole front, joints included, is then colored with a compound of copperas and a pigment of the color required, or the front is rubbed with a piece of soft brick till the bricks and the joints are of one color. While lime putty is pressed on to the joints in straight lines, with a jointer worked on a beveled edge straightedge, and before the latter is removed, the edges are trimmed with a tool called a Frenchman, which usually consists of an ordinary table knife with the end of the blade turned up at right angles to the remainder. The edge of the knife cuts the putty, and the turned up end drags off the superfluous stuff, leaving a white joint ¼-in. in width and $\frac{1}{16}$-in. in thickness on the face of the work. This is not the best method of pointing if the bricks are sound and their edges sharp and regular; but if the edges are broken, the joints, when stopped, appear very wide and irregular, and are thought by some not to look well if the above process were not adopted. This method should never be permitted.

Bastard Tuck Pointing is the name given when a

ridge ¼ in. to ⅜ in. is formed on and off the stopping itself, as shown in Fig. 146, K.

Masons' V Joint, Fig. 146, L, shows the usual joint used for masons' work.

CHIMNEY BREASTS, FLUES, ETC.

These have to be formed according to the design of the house; but in most cases, for the sake of economy in space, etc., the fireplaces are built, one over the other, from floor to floor, and frequently in party walls, the latter being the wall which divides house from house. The openings will differ in size, according to the range or grate used. For example, a full sized range would require an opening 4 ft. wide and 1 ft. 10½ in. deep; the extra depth, beyond what is required for the flue, being lost when the flue is in position by arranging a set-off in the breast to form a mantel-shelf. For an ordinary register stove the opening would be 3 ft. wide by 12 in. deep, and so on, and, unless provision be made by a breast breaking out upon the outside of a building, a projection or breast must be formed inside the rooms to receive the stoves and provide for the flues. The back of the fireplace should not be less than 9 in. in thickness; therefore the projection of the breast depends upon the thickness of the main wall and style of stove to be used. That is to say, if the depth of the fireplace be 1 ft. 1½ in., then in an 18-in. wall with a 9-in. back to fireplace, the breast would project 4½ in; in a 14-in. wall, 9 in., etc.

It is most desirable to have as much bend as possible in flues; not to have the flues larger than is necessary (a kitchen flue should be 14×9 in., an ordinary living room 9×9 in.); to gather in quickly above the arch.

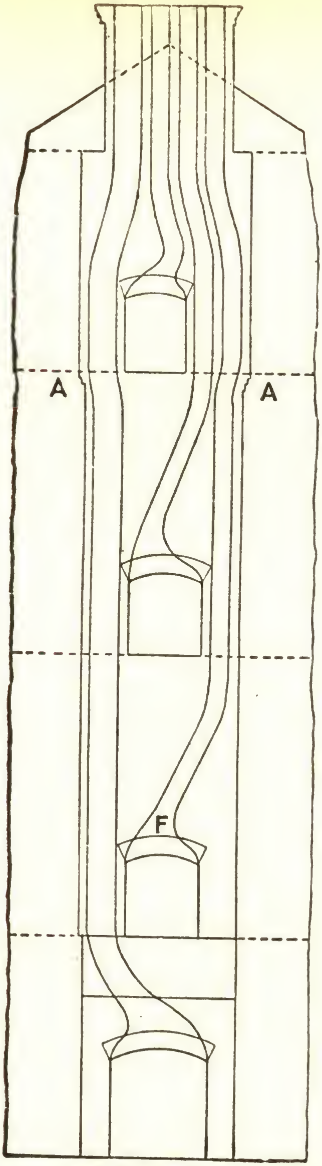


Fig. 147.

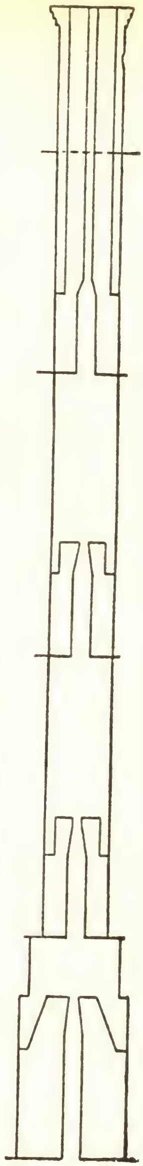


Fig. 148.

though not so quickly as to form a nearly flat surface immediately above the fire; and to have perfectly easy bends, with no abrupt angles. For a flue to successfully do its work, smoke should be treated as though it were water. Sharp turns and breaks interrupt the

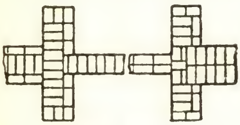


Fig. 149.

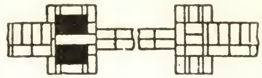


Fig. 150.

easy flow of the smoke, causing it to eddy round, choke the flue, and return again to the room. The inside should be smoothly rendered with pargeting, i.e., cowdung and lime, in the proportion of 3 to 1.

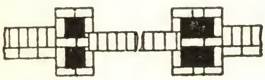


Fig. 151.

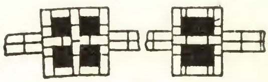


Fig. 152.

This makes a smooth surface, is tough and is supposed to prevent the smoke stains and heat from coming through the wall. Ordinary mortar, however, is now more often used than pargeting. Fig. 147 is the sectional elevation of fireplaces over each other, as far as is possible, in a double-breasted wall; Fig. 148 being a cross-section taken through the double breast; Figs. 149, 150, 151 and 152 are plans of the same on the basement, ground, first and second floors; while Fig. 153 is a plan through the stack.

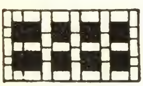


Fig. 153.

Chimneys and flues may be constructed at any angle on condition that any flue inclined at an angle less than 45 degrees is provided with suitable soot doors.

Mistakes are often made in constructing flues

through not carrying them fast enough to the right or left, as the case may be, so as to prepare for the fireplace above; then, when the mistake is discovered, they are carried over quickly, and a flat surface is formed, resulting in a faulty flue. To obviate this, an easy calculation should be made as soon as the flue is gathered over and brought into position above the fireplace. Taking Fig. 147 as an instance, the flue being in position 2 in. above the arch, measure the height to the fireplace above, and the distance the flue has to be taken to the right or the left; or, in other words, ascertain how many inches it has to be taken laterally to the foot vertically. In the case in point, F is the flue in position in the middle of a 6-ft. 4-in. breast. The distance to the fireplace above is 6 ft. and the 9-in. flue has to be carried to the right, allowing 4½ in. outside work. Then it is evident that the left side of the flue has to be carried a distance of 2 ft. in 6 in. or 24 in. in twenty-four courses, to get into position; that is to say, the flue must recede on the under side, and sail over on the upper, 1 in. in every course.

Fireplace Jambs.—When starting the fireplace in the basement, the jambs on each side will be solid, and are usually 14 in. on the face by the depth as already described. The flue, being taken either to the right or to the left, will appear upon the next floor as a jamb 18 in. on the face. This allows 4½ in. outside work, and a 9-in. flue. If, however, the flue should be 14 × 9 in., then the jamb will be 23 in. on the face.

As already stated, fireplaces vary from 2 ft. 6 in. to 4 ft. in width, according to the stove to be used; and they will also vary in height, that for a kitchen being 4 ft., and for an ordinary register 3 ft. high. When

the proper height is attained, an iron chimney bar is placed in position. This slightly curved bar (Fig. 154) is 3 in. wide, ¾ in. thick, and rests 4½ in. each end upon the jambs, the ends also being split and turned half up and half down into the brickwork. An arch of two or three half-brick rings is then carried over upon the chimney bar, and the work continued above it (Fig. 155). Instead of the iron bar, lintels of coke breeze and cement, or an arch turned on a temporary turning piece, is now frequently used.

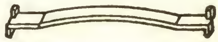


Fig. 154.

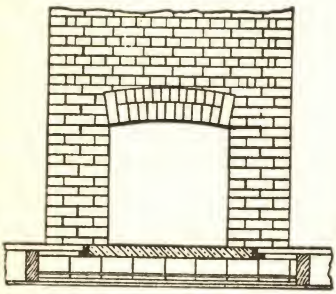


Fig. 155.

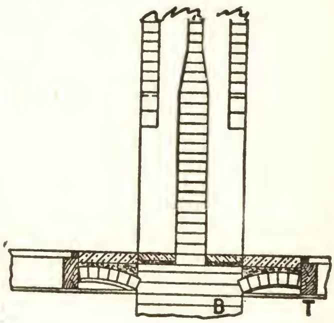


Fig. 156.

Mode of Carrying the Hearth.—The hearth should be at least 18 in. wide, and extend beyond the fireplace opening 6 in. each way. There are several methods of supporting the hearth, but the most usual is by means of the trimmer arch. Turning pieces are fixed in between and at right angles to the trimmer T and the breast B (Fig. 156), covered with thin lagging, seen in section in the last named figure; the arch, consisting of rows of stretchers on edge and parallel to the breast, is then carried over and properly keyed in (see Fig. 157, which is a horizontal section taken

through the fireplace, and showing the trimmer arch on plan). Another good system is that of tee-irons with the table turned downwards, fixed in between the trimmer and breast, sheeted with temporary boarding underneath, and filled in with concrete. Fig. 158 is a longitudinal section taken through such a hearth. Or the tee-irons may be fixed as already described, but kept such a distance apart as to allow a plain tile to be placed in between two adjacent webs lengthwise. Three courses of these tiles should then be laid and properly bonded in Portland cement and sand. Fig. 159 is a cross-section illustrating the latter system. In each system the surfaces are brought to with concrete to within ½ in. of the under side of the hearth, the ½ in. being allowed for bedding. The back hearth, when there has been no breast below, will be treated in the same way as the front, but in all other cases will be bedded on the brickwork.

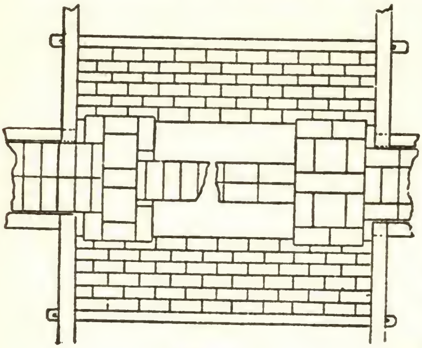


Fig. 157.

Every flue should be complete in itself, for if opening be left in the 4½-in. walls—or withes, as they are termed—which part flue from flue, the smoke will enter the flue not in use, and a down current will take it into the room.

Coring-holes 12 × 9 in. should be left, and temporary boards fixed in each flue and upon each floor, for the

purpose of clearing out the rubbish that may fall down the flue during the building.

Corbeling.—If it should be necessary to increase the width of the breast, this may be done by corbeling the brickwork between the floor and the ceiling. By sailing over 1½ in. per course on each side for three courses, the breast may be increased 9 in. (Fig. 147, A A). When anything beyond this is required, then stone corbels should be used. If the fireplace jambs are not carried up from the basement upon solid foundations, but grow out from the party wall, as it were, by means of corbeling, then the breast may project the thickness of the wall upon which it depends.

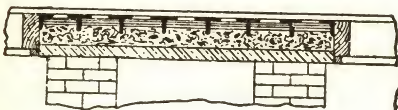


Fig. 158.

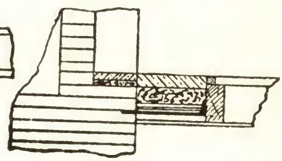


Fig. 159.

Hard stone corbels are really more reliable than brick corbeling for this purpose.

When the chimney breast has taken in all the fireplaces and flues required, and appears above the topmost ceiling, the flues are brought into the position in which it is desired they shall be seen when above the roof. This, when out of sight, is done by dropping off the superfluous brickwork in offsets. But when the breast appears as a projection upon the outside of the building, then one method of reducing it is that shown in Fig. 160.

Bond in Chimney Stacks.—Though it is far preferable to have 9-in. outside work to chimney stacks, to keep out both the rain and the cold, which retard the even

flow of the smoke, yet it is more often that the outside work is 4½ in. only. In bonding stacks, the desired end to be kept in view is that the withes or partings shall be tied in, so as to strengthen what might otherwise be a very weak construction. When the flues are surrounded with 9-in. work, either English or Flemish bond may be adopted. Figs. 161 and 162 are plans of alternate courses of the first, and Figs. 163 and 164 of the latter. It is with 4½-in. work outside that the great difficulty occurs, and up to the present a broken kind of bond, called chimney bond, in which the withes

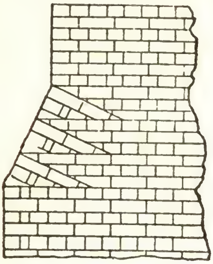


Fig. 160.

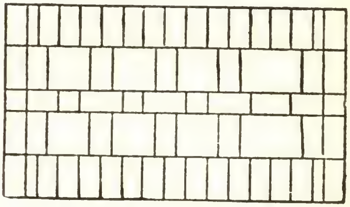


Fig. 161.

are indifferently tied in, has been used. In this bond a whole stretcher is used upon the quoin; but by sacrificing the small amount, if any, of extra strength derived from the use of the stretcher upon the quoin, and substituting a three-quarter bat in the stretching course, instead of using a closer in the heading course, the work may be built either in English or Flemish, and a perfect tie and bond be secured. (See Figs. 110 and 111 for plans of alternate courses of English, and Figs. 112 and 113 for the same in Flemish bond.)

According to some strict building acts, chimney shaft or smoke flue shall be carried up to a height of

not less than 3 ft. above the roof, flat, or gutter adjoining thereto, measured at the highest point in the line of junction with such roof, flat or gutter. And the highest six courses of every chimney stack or shaft shall be built in cement.

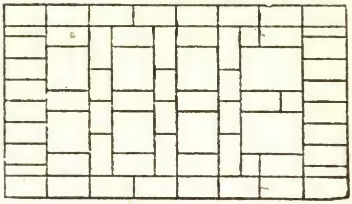


Fig. 162.

Setting Ranges.—Built in and close fire ranges are many and varied in description; but there are general rules for guidance in setting them that are applicable to nearly all. Double-oven ranges are of course the largest, and the American or self-setting range the smallest. With the latter but little skill is required, while the setting of the former is somewhat difficult.

To proceed to set a range, the first necessary operations are to properly level in a hearth or course of brickwork to take the oven cases; to temporarily place the range in position so as to mark the flues, etc., and to build in beneath each oven case sufficient brickwork to allow a 2-in. cavity below the oven. It will be found that the heat from the furnace traverses the top of the oven, and is then induced to descend on the outside or end of the range to the front of the check, which is a piece of sheet iron fixed diagonally on the bottom of the oven, and coming from the back extreme corner to within 4 in. of the front of the soot door in

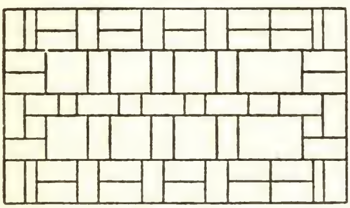


Fig. 163.

the face of the bottom of the range, and centrally beneath the oven door. The flue at the end should cover as much surface as possible, and should not exceed 2 in. wide by the length of the side of the oven, the object being to keep the heated air and gas as close to the oven and over as wide a surface as possible.

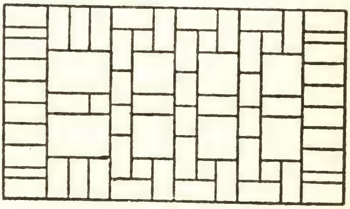


Fig. 164.

It has been described how the flue is formed to the front of the check; it is then allowed to go to the center of the back at the bottom of the oven, and from that point is taken up in a flue usually 9 in. or 10 in. wide and 3 in. to 4 in. deep, which ascends vertically to the damper, which is placed at the top of the back coving. The covings are sheets of paneled cast iron that encase the recess above the top plate, the covings, in their turn, being

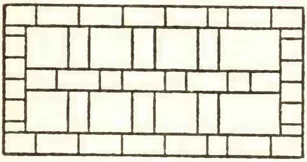


Fig. 165.

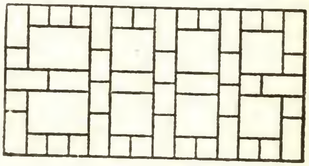


Fig. 166.

covered with a top plate. They are usually fitted with a plate rack, and should be bedded with mortar against the insides of the jambs and the brickwork at the back which is formed between the flues.

The boiler is set on a benching of fire-brick built at the back of the ash pan and is usually arranged with a flue from the bottom of the furnace to the back of the

range, and a vertical flue formed in a similar manner to the oven flue up to a damper placed at the top of the back coving. The boiler, which should be of wrought iron, is drilled and tapped for the connecting of the hot-water circulation.

These are general methods, but special kitcheners often require different treatment. In every case there should be no sharp turns in the flues, and the top flues should be carried above the dampers in the direction of the chimney flue above.

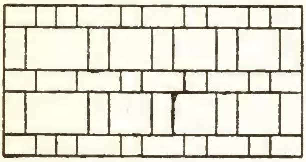


Fig. 167.

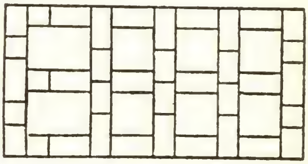


Fig. 168.

Register, Mantel Register, and Interior Stoves.—The main object in fixing these is to fill up with brickwork the space which, in the fireplace opening, is not occupied by the stove or flue. In some cases the register is placed in position, and set by filling in the brickwork through the register flap which forms the entrance to the flue for the smoke. These are often insufficiently filled up, thereby leaving a large cold-air space at the top, which causes the smoke to be checked and sent back into the room, instead of pursuing its proper course up the flue.

For interior grates with fire-lump backs, the shape of the back of the lump should be marked out upon the hearth, and brickwork built up to the shape, allowing for a mortar bed at the back of the lump. Here, again, it is important that the opening should be filled up as much as possible, leaving only the size of the flue.

ARCHES AND GAUGED WORK*

Gauged work consists in rubbing and cutting to any required shape specially made bricks, or "rubbers," as they are technically termed.

This class of work is usually done in what is called a cutting shed, provided with a bench about 2 ft. 3 in. high and 2 ft. 6 in. wide.

The tools and appliances required are a rubbing stone, circular in shape, and 14 in. in diameter; a bow saw fitted with twisted annealed wire No. 18 gauge, parallel file 16 in. long, small tin scribing saw, square, bevel, straight pieces of gas barrel for hollows in mouldings, etc., bedding slate to try the work for accuracy, straight-edge, compass, setting trowel, putty box (Fig. 169), boaster, club hammer, and scotch (the three latter for axed work), reducing boxes for thickness (Fig. 170), and for length (Fig. 171), moulding boxes (Fig. 172), boxes with radial sides for obtaining the wedge-shaped voussoir according to the template (Fig. 172½), a setting-out board about 6 × 5 ft. and lining paper 2 ft. 6 in. wide, etc.

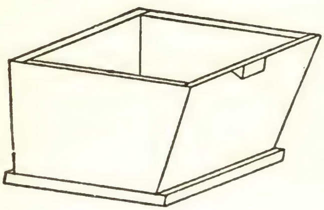


Fig. 169.

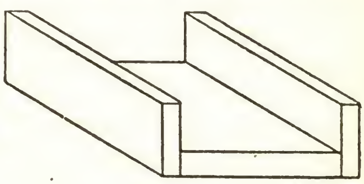


Fig. 170.

The most elementary kind of gauged work is that

*This department is largely taken from H. W. Richards' work on "Brick-laying and Brick-cutting."

which is known as plain ashlar, consisting of heading and stretching courses for plain facing. The operations are as follows: first bed the brick, i.e., place the brick with the letter or hollow side on the rubbing stone; then, holding the brick with both hands, rub it upon the stone, giving it a circular motion from right to left, and trying it occasionally with a straight-edge till the bed of the brick has become a perfect plane.

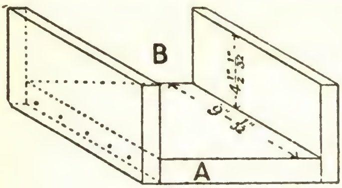


Fig. 171.

Next, with the rubbed bed turned from the body, place the side or face of the brick upon the stone, and rub as before, at the same time endeavoring to make the side square with the bed, testing it by application of the square, stock to the side, and the blade to the bed of the brick. Then serve the head in the same way, making it square with both bed and face. After these operations are perfect, the brick has to be reduced to thickness; this is done by placing it on its bed in a reducing box (Fig. 170), the measurement of the inside depth of which is $\frac{1}{16}$-in. under 3 in., sawing off the superfluous material and finishing with a file.

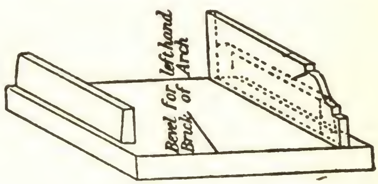


Fig. 172.

If for a stretcher, next place the brick face downwards in a 9-in. lengthening box (Fig. 171), making the square end to coincide with the front edge A of the box, and saw off to length, finishing with a file at

the back edge B. The cut stretcher will be 9 in. less $\frac{1}{32}$ in. in length.

In preparing long headers, the brick would have to be placed in the same box, face downwards, but the saw and file would be used along the top edge of the box, thus making the header 4½ in. less $\frac{1}{32}$ in. in width. If for bat headers, then the squared end is placed downwards in the box, and saw and file used along the top edge again.

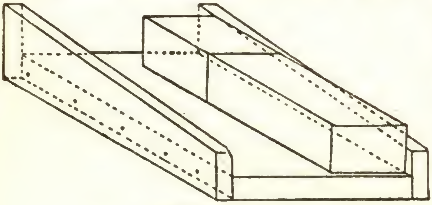


Fig. 172½.

Arches.—These may be plain, axed or gauged.

In plain or rough arches the bricks are not cut at all; the joints alone give the radiation, and the arch is usually made up of rings.

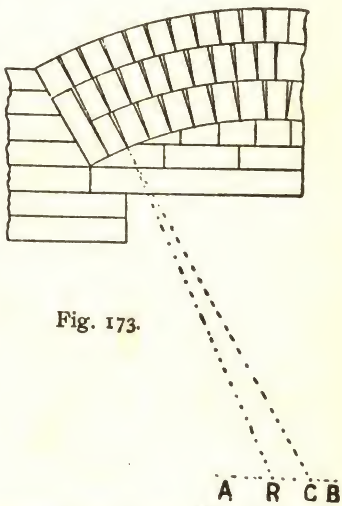


Fig. 173.

The Relieving Arch.—The relieving or discharging arch (Fig. 173), as its name implies, is used for the purpose of relieving the weight from any portion of the building which is too weak to bear it, and discharging or transmitting it to piers, etc., specially prepared to receive the load. They are sometimes used in the face of build-

ings, when they are also treated as ornamental features.

The most frequent use for the relieving arch is inside the building, over door and window openings. The opening is first bridged by the lintel, which should rest not less than 4½ in. upon the jambs each side of the opening; next a brick core is built throughout the entire length of the lintel, to serve as a turning piece for the arch; the curve being obtained by means of a curved mould having the same rise it is intended to give the arch. This is applied to the face of the core; the bricks are marked, and then cut to shape. A skewback, which should radiate from the striking point, is built at each end of the lintel; and the arch, consisting of 4½-in. brick rings, but starting with a stretcher at each end upon the skewback, is then turned over the core. When a flat rise only is given, the brick core is done away with, and the curve is worked upon the lintel.

It must not be forgotten that the lintel is in length the exact span of the arch; that the object of the lintel is for the purpose of fixing the joinery; that the core acts only as a turning piece for the arch, and to fill up the space between this and the lintel; and that neither of them influences the strength of the discharging arch in any way. Should a fire occur, the lintel would burn and the core fall, but the arch ought to remain intact. The method of striking out the arch will be the same as that given for the segment.

When arranging the rings, those starting from the top and working downwards alternately should always have a key-brick; the other rings will key in with a joint. As already stated, in this as in all other rough arches, the bricks themselves are square, and the radiation is obtained by means of the joint. The

mode of drawing the radial joint is as follows: prick over the 3-in. courses and fill in the face from the radial point R, as in the semi-arch. Through the radial point, and parallel with the lintel, draw an indefinite line A B; make one of the courses or bricks of the arch parallel, by keeping the *top* equal to the *bottom* of the brick; produce the line which does this so that it cuts the line A B, in C, then C will be the point by means of which a line drawn from it through the soffit end of the face joint of each course will give the radial joint. This method must be followed each side of the arch.

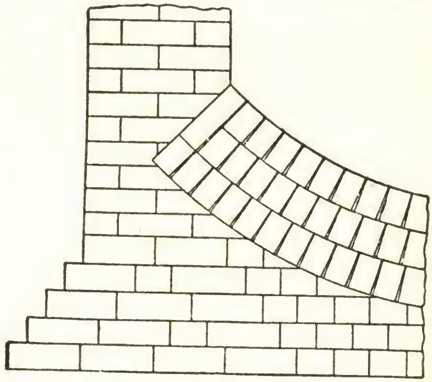


Fig. 174.

The Invert Arch.—It often occurs that the principal loads in buildings, such as girders carrying the floors, etc., are concentrated upon certain points, as piers, for instance, which are usually strengthened to receive them. Should there be openings upon each or one side only of the pier, it is very evident that the weight of the pier and its load would be taken vertically downward to one part of the footings only, little able, perhaps, to bear it.

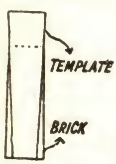


Fig. 174½.

To relieve the special part of some of the weight, by spreading it over a larger area of footings, invert arches are used, as in Fig. 174. Here

some of the weight is taken from the pier A and its fellow, and transmitted, by the invert arch, to the footings in between them. It will be noticed that the lines from the radial point to the skewbacks form an angle of 45 degrees, this being found to be the best angle to receive the weight.

Chimney breasts in basement stories are often treated in this manner.

Egg Shaped Sewer (Fig. 175).—This sewer, as its name indicates, is shaped like an egg, with the smaller end downwards, this shape being found the best adapted for the varied charge of sewage. It matters little whether it be during a time of storm water, or during a dry season, when there is but small quantity of sewage, there is always a sufficient depth of matter to ensure a perfect flow. The sewer may consist of two or three 4½-in. rings of brickwork, with a terra cotta or hard-brick invert; bedded in concrete. The mode of setting it out is as follows: Let AB be the diameter of the head, or crown, then CB will be the radius, and C the radial point; measuring out from the center C to the left and right of A and B, a distance equal to AB, will give the radial points D and E, from which the curves of the sides may be described; then, for the invert, draw from the point C at right angles to AB a line CF equal to AB. By dividing CF into four parts, the radial point G will be found. The termination of the sides x, x, and the beginning of the invert is determined by lines passing from D and E through G. The 4½-in. rings will be arranged

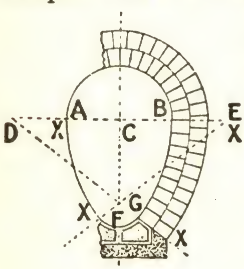


Fig. 175.

as in the relieving arch, the outer rings having the key bricks, one at the crown, the line FC passing through the center; and what might be termed two keys, one on each side, the line DE passing through their centers; the next ring towards the inside having straight joints at these points; the next inner ring, keys, and so on.

Axed Arches.—Axed arches are really roughly cut gauged arches with a $\frac{3}{16}$-in. mortar, instead of a $\frac{1}{32}$-in. putty joint. Therefore, the mode of obtaining the template and the system adopted for gauged arches generally, applies equally well to axed ones; the only difference being that when the bricks are hard, the brick will have to be scribed each side to the template and across the soffit with a tin scribing saw, and cut off to the scribed lines with a boaster (sometimes called bolster) and club hammer upon the banker, and the remaining

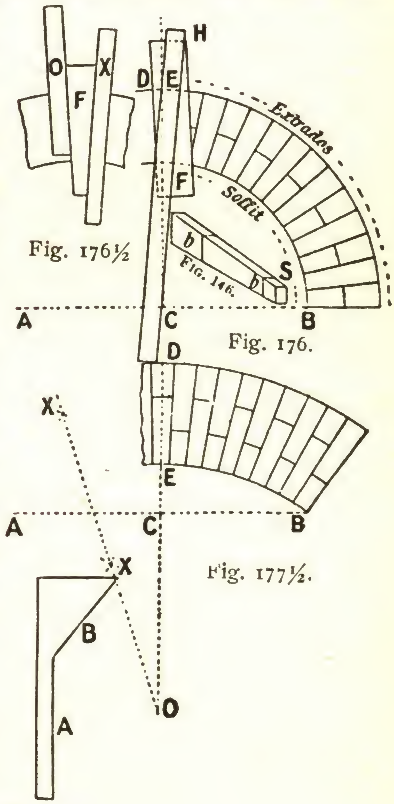


Fig. 176½
Fig. 176.
Fig. 177½.
Fig. 177.

material between the scribed and boastered lines neatly axed off with a scotch (sometimes termed scutch).

In arches in which the end or soffit may not be cut to a bevel, such as glazed bricks, etc., the mode of applying the template to the face of the brick is somewhat different. It would simplify the matter, perhaps, if, after the template was obtained, as described, the bottom of the template were to be cut off to the cutting mark, and made to fit the soffit line of the drawing of the arch and then applied to the face of the brick, the brick and template both being on end, and both the bed and back of the brick cut off to the template. That is to say, both edges of the template would be cutting edges (Fig. 174½, which shows the template in position for cutting the brick).

Gauged Arches.—Throughout this work one principle is adopted for setting out and obtaining the templates for all gauged arches, and by careful attention to the instructions given, all practical men should be able to gain a perfect mastery of the subject. Whenever the compass is mentioned, it will be understood that in full-size work the radius rod would be used, and although, when describing the construction, the whole of the arch is alluded to, a half only is drawn, as would be the case when setting out in practice.

The Semicircular Arch.—This arch is known always as the semi (Fig. 176), the opening here being 3 ft., the face 9 in., and the soffit 4½ in.

Construction, etc.: Draw an indefinite base line; upon and perpendicular to it erect a center line; upon the base line set out the opening AB, half each side of the center line; then with the point of the compass at the center C, and the pencil at B, describe the

larger half of the soffit, or intrados, and with the point still at C, but the pencil extended 9 in. beyond B, describe the outer line or extrados. In most rubber bricks the brick and joint together will hold out or measure 3 in. Therefore take a distance of 3 in. in the dividers, and starting with half the distance each side of the center line on the extrados, prick over till the courses come home exactly to the springing line, increasing or decreasing the distance taken in the dividers, i.e., making it slightly over or under 3 in.; but always taking care that the first pricking, or key-prick, shall be equally divided half each side of the center line. Call these first two prickings D and E. From the center C, through D and E, draw the approximate key, but producing the line through E to H. This approximate key will also be the shape of the trial template.

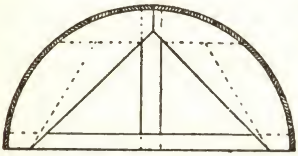


Fig. 178.

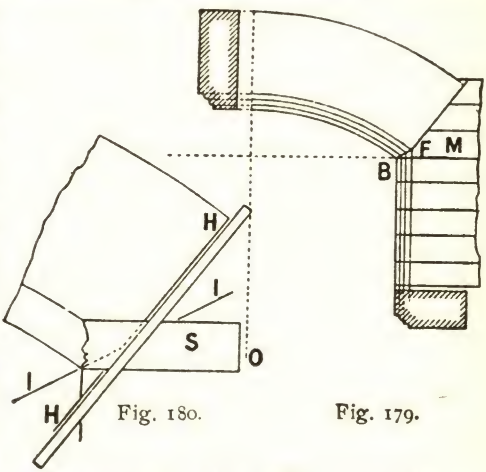


Fig. 180. Fig. 179.

To obtain the template the following pieces are necessary: two small straight-edges $16 \times 2 \times \frac{1}{2}$ in., and also a piece of board $14 \times 3\frac{1}{2} \times \frac{1}{2}$ in., with both sides

planed and one edge shot square and true. Place the latter, which may be termed F, Fig. 176, with the shot edge against the line radiating from C to D, and with a long straight-edge having the end of one edge against the radial point C, and the other end coinciding with the produced line H, and laying over F, mark the latter the shape required. Having cut and shot the template to the line drawn upon it and square with the face (when it will appear as F, Fig. 176½), proceed to traverse it; i.e., see that in pricking over there are fourteen courses in half the arch, including the key; ascertain whether fourteen such templates

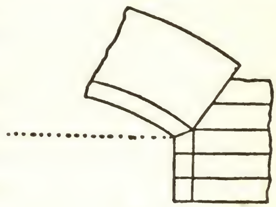


Fig. 181.

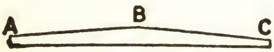


Fig. 182.

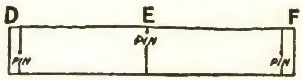


Fig. 183.

will exactly fill half the arch, starting with the key and terminating with its edge upon the springing line. The way to traverse the template is as follows: Place the template upon the approximate key, taking care that it exactly fills it; draw a pencil line, which will be known as the filling in mark,

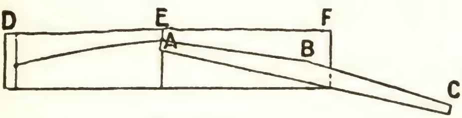


Fig. 184.

across the left-hand edge of the template and immediately over the soffit line. Next place the two straight-edges O and X one upon each side of and tight up to the template, always keeping O a

little above the filling-in mark, Fig. 176½. Keep X firmly in its place, remove the template, slide O against X, remove X, place the template against, with the filling-in mark on the soffit line; place X against it, remove the template, slide O against X; and repeating this movement till the right-hand edge of the template comes out to the springing line. Should the template at the last turn be parallel to the springing line, but not quite home to it, bring the template down a little by placing the filling-in mark higher up. The top may come over the springing line, and the bottom reach or not quite reach home; then a shaving or two must be taken off the top, or if the bottom comes over, then a few shavings off this. Each time it becomes necessary to alter the filling-in mark or the template itself, it will be necessary to traverse again, taking care always, at the start, that the template is equally divided, half each side of the center line. When the template has been obtained, line in the joints of the arch with it. The next important matter is to allow for joint. This is done by placing the edge of the template against the radial line CD, backing it up with the straight-edge O kept firmly in position; then, by sliding the template up against the latter, it will recede from the radial line CE. If for axed work the template may be worked up till it leaves the radial line CE by $\frac{3}{16}$ in.; if for gauged work, by $\frac{1}{32}$ in.; then, in a similar way to that in which it was marked for filling in, scribe for cutting mark immediately over the soffit line, Fig. 176, S. When for gauged work, to prove that the amount allowed for the joint is correct, traverse the template again, with the *cutting* mark on the soffit line, for four courses, when, if it leaves the fourth line by ⅛ in., it may be taken

as correct. In this arch the lengths of all the courses are alike, and may be taken on the edge of the template, bearing the cutting work; this edge being termed the cutting side of the template, and the other the bed, coinciding in this respect with the arch-brick itself. Place the bed of the template against the radial E, with the cutting mark upon the soffit line, then on the cutting side make a mark on the edge immediately over the extrados (these marks should always be squared across). While the template is in this position, the bottom and top bevels B may also be obtained, by making similar squared lines on the bed of the template, and then connecting these on the face, as in Fig. 177½.

In using the template, the soffit bevel will be taken off by placing the blade of the bevel or shift stock against the bed of the template, the blade pointing towards the soffit and agreeing with the line upon the face of the template. It is advisable to write the size of the opening, the name of the arch, and the number of courses upon the template, and also to apply the center (Fig. 178), upon which the arch will be turned, to the striking out, ticking off the courses upon it, and squaring them through; this will act as a guide to keep the proper thickness of joint when setting the work. The setting out should be on lining paper, which may be saved for future reference.

How to Cut a Semi-Arch.—Bed the brick and square the face; square the head from the face, but bevel it from the bed, the stock being placed against the bed, and the blade to the head. These bricks must be prepared for right and left hand; that is to say, with the face of the brick turned towards the body, half the beds should point towards the right and half towards

the left. Then prepare a radiating box 10 in. wide in the clear, and rather longer than the template, the sides of which, worked from a square line across the bottom, radiate exactly as the template, Fig. 173, also having the cutting mark upon each side exactly opposite each other. Great care must be taken that the box is accurate, and it is advisable to try the first radiated brick upon the bedding slate, with the original template. Two bricks, right and left hand, may be placed in the radiating box, with their faces to the sides and their soffits to the cutting marks, and sawn close to the top edges of the sides of the box (the latter being protected with tin), and finished with the file, taking care to file away from the front arris of side of the box, so that the former may be perfectly sharp; then, in a lengthening box (Fig. 171), face downwards, and with the soffit placed tight against a straight-edge held across the end, cut off to a length of 9 in.

If the arch is more than 9 in. on the face, then, before radiating, the course must be made up in length. Taking an arch 12 in. deep on the face, as an instance, and dealing with a course having a stretcher towards the soffit, the stretcher will be cut off 8 in. in length, and the opposite bevel obtained in the lengthening box. A bat over 4 in. in length, bedded, faced and beveled, will be fitted to the top of this, the template applied, the brick scribed to the length of the cutting side, and to the square mark on the bed, the two marks on the brick connected by the scribing saw, and sawn off square with the face. By this means the course is cut off to length, and the top bevel obtained at the same time.

It mav here be noted that the 9-in. lengthening box

can be used for any odd measurements, by nailing a stop or fillet across the bottom of the box and parallel to one squared end, according to the length required, the worked end of the brick being placed against the stop, and the piece not required cut off to the end of the box.

For an arch having a 9-in. soffit, it will be readily understood that a face stretcher would have to be taken to a depth of 4½ in. in a reducing box and backed up with a properly squared and beveled bat, and that for a soffit stretcher the brick would be bedded, the face beveled for the soffit, and the header, acting as the face, squared from the bed and soffit. By placing this brick soffit downwards in a reducing box 4½ in. deep, the opposite bevel, after sawing, would be worked upon it; being afterwards made out, on the face, by a bedded, squared, and beveled bat, and cut off to length, to the template.

Every arch should be keyed in with a stretcher towards the soffit; and it will be found that, counting the courses in half the arch, and including the key, if there be an odd number, then there will be a stretcher, for the start or upon the skewback, and a stretcher for the key; if an even number, then a header for the start, and a stretcher for the key.

Arch with Moulded Soffit.—In arches with moulded soffits, although the end in view, with respect to bevels, etc., is the same, the mode of working is somewhat different. The section of the mould required must be cut upon two boards, $10 \times 4\frac{1}{2} \times \frac{1}{2}$ in., screwed together, the edges shot and squared, and the moulding cut upon them while thus fixed, so that they shall be exactly similar; the edges representing the face and soffit may be protected by tin, and they

should be fastened one on each side, exactly opposite each other, to a box having a stout bottom and two sides only, and being about 10 in. in the clear after the moulds are fixed (Fig. 172), the bricks being properly bedded and roughly squared upon the side which is not intended to be the face. The bevel is taken from the template in the usual manner, and marked upon the bottom of the box, both right and left, with the back of the stock against the front edge of the box and the hind part of the blade on the bottom; the roughly squared edge of the brick between the roughly squared face and the bed is fixed against the line or lines thus marked (if there be room, two bricks at a time may be cut, one for right hand and one for left); the saw is taken through the moulded soffit and the top face, and then with file, barrel, etc., the brick is finished, being beveled, moulded and faced at the same time. When the brick is taken out of the box, should the soffit, or face, be not quite true, the bed is rubbed to fit *them*, the square and bevel being used for this purpose. The remaining operations are the same as in plain-gauged arches.

Setting.—The center, Fig. 178, having been fixed with folding wedges beneath it, so as to make it easy of careful removal after the arch is set, should be tested for accuracy.

Axed arches are set in fine mortar, the joint being either struck, or raked out, and afterwards pointed, to give it a fancied resemblance to gauged work. Gauged arches and gauged work generally are set in lime putty, as already described. The putty is served to the setter in a putty tub. This is a box open at the top and with beveled sides, being about 15 × 12 in. at the top, but smaller at the bottom, and about 9 in.

deep (Fig. 169). The setter, keeping the putty frequently stirred, and having knocked and brushed the dust off the brick, holds it lightly on the top of the putty, takes up just sufficient to form the joint, removes a small quantity from the center, makes the joint true at the edges, puts the brick in position, and lightly taps it to make it solid. Arches are started from the right and left hand, and worked up towards the key, which is put in last. When the arch is completed in its place, it is grouted in with Portland cement, a joggle having been formed in the brick by cutting a groove 1 × 1/4 in. in the middle of it; this grouting in with Portland cement greatly strengthens the arch. In years past, a bead was formed with the joint, and the work left. But now, any irregularity in the face, mouldings, etc., is corrected by means of files, pieces of barrel, brick, handstone, etc., both brick and joint being left flush and brushed down with a soft brush.

The Segment Arch (Fig. 177½).—Opening, 3 ft.; rise, 6 in.; face, 12 in. Draw an indefinite base line, and at right angles to it above and below draw an indefinite center line. Upon the base line set out the opening AB half each side of the center line CD, and above the base line measure off the 6-in. rise in E; then with the point of the compasses at A, and taking any distance greater than half AE, describe arcs above and below the base line; with the same distance in the compasses and the point at E, cut these arcs in X. Then a line being drawn through these intersections and meeting the center line, will give the radial point O.

With the point of the compasses at O, and the pencil extended to A, describe the soffit, passing through E and terminating at B. Next with the straight-edge at O and passing through A, draw the skewback or

abutment, and the same with B; then measure up from the soffit upon the center line 12 in., and with the point of the compasses at O, and the pencil extended to the 12 in., draw the extrados terminating at the skewbacks. Now proceed as in the semi to procure the template, with this exception, that the work terminates on the skewback, and not on the springing line. Having procured the template, fill in the arch. The courses will be divided into 8-in. stretchers and 4-in. headers, taking care to key in with an 8-in. stretcher towards the soffit. This arch having a skewback, care should be exercised that this is properly cut and set,

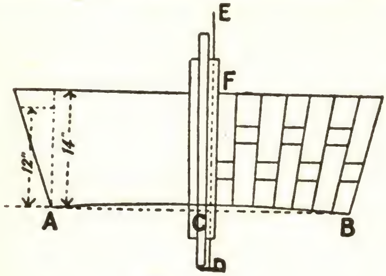


Fig. 185.

especially if it be in ordinary building bricks. A mould or gun, as it is termed, should be taken off the drawing and applied to the reveal; the projecting or triangular portion answering to the fall of the skewback (Fig. 177½). Here A being placed against the reveal, the skewback is built up to B.

In this, as also in the semi-arch, if the student wishes to draw the arch only, then the extrados may be pricked over at 3 in. as already described, and the face joints filled in from the radial point by means of a straight-edge passing from it to the divisions on the extrados.

Moulded Segment.—When a moulding is worked upon the reveal and continued round the soffit of the segment, a new difficulty presents itself in the intersection

of the mouldings between these two. Again, take a 3-ft. opening, 6-in. rise, 12-in. face, with a 2¼-in. moulding, the half being shown (Fig. 179). Set out the soffit and reveal as in the plain gauged segment; then to the right of the reveal line measure off the depth of the moulding 2¼ in., draw the outside moulding line parallel to the reveal line, and continue above the base line. Then on the center line and above the soffit again measure off the 2¼-in. moulding, and with the point of the compasses at O and the pencil extended to the 2¼-in., describe the moulding line parallel to the soffit, and meeting the reveal moulding in point F. From the point F to B draw a line. This will be the miter line. The skewback will be taken, as before, from the point O, but will begin at the point F. The arch will be cut precisely in the same way as the moulded semi, with a slight addition to the top course of the moulded reveal and the first course of the arch, i.e., where the intersection takes place. Two pieces of board, 10 × 3 × ½ in., should be planed and shot while screwed together, so that they shall be perfectly true in themselves and to each other; the lines H and I will be produced each way and the moulds laid to coincide with the bricks S, Fig. 180; then by means of the straight-edge, which is made to coincide with the produced lines as shown, the lines H and I will be accurately drawn upon the moulds. They should then be cut to this shape, and are known as shoe moulds. A moulded brick, being placed on its bed in between two shoe moulds, can, by means of the saw and file, be properly mitered as M, Fig. 179; the moulded end of No. 1 course of the arch should be then cut to tightly fit it. All other operations for the moulded segment will be the same as in the moulded semi.

In axed arches with field-moulded bricks (bricks having the moulding cast upon them in the brick-mould while in the green state, and afterwards burnt), such as bull-nosed and mopstaff beaded, the treatment of the miter will be nearly the same, only, that instead of the miter being solid, as in M, Fig. 179, the portion BF in the latter figure will be cut upon the top of the brick, and the skewback taken from that, Fig. 181.

Camber Arch.—This is sometimes called a straight arch; but it has really a slight rise, the rule being to give the soffit a rise of ⅛-in. for every foot of opening. The reason for giving the rise is to counteract the optical illusion which causes the arch, if straight upon the soffit, to appear to sag, or camber, the wrong way. When a slight rise is given, the arch appears to be straight upon the soffit. It would be impossible to strike such a slight sweep with a radius rod; the rise is therefore given by means of the camber slip. A camber slip should be made of good hard wood that will not shrink or twist; mahogany or oak is excellent for this purpose. It is always convenient to keep one in stock, and if it be long enough it will answer for any opening. There are not many camber arches over 7 ft.; therefore a convenient length for the camber slip would be about 8 ft. The mode of obtaining the camber slip is as follows (an extreme case is given, as being easier of illustration): Suppose the opening to

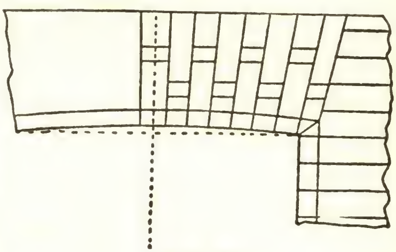


Fig. 186.

be 3 ft., and the rise 1 in. to the foot, then the camber slip 3 ft. long would have a rise of 3 in.; take a rod 3 ft. long, measuring in width 1 in. at each end and in the middle 2½ in., or in other words, having in the center half the required rise; shoot this piece from the middle to the two ends perfectly straight, thus forming two triangles, as it were, upon a common base; call the center B, and the two outside points A and C (see Fig. 182). Then take a piece of board a little over 3 ft. long and 6½ in. wide by ½ in. thick, planed both sides, and one edge shot, draw a center line upon the face of it, and 18 in. each side of it draw two other lines; call the center line E, and the two outside lines D and F, Fig. 183. Upon the center E, 6 in. up from the shot edge, drive in a pin, and upon D and F, 3 in. up from the shot edge, drive in other pins. Then take the first piece, Fig. 182, already prepared, and with a pencil held at the center B, apply it to pin F, and with A on the same piece pressed against the pin E, move the piece with the pencil from F to E, describing half the curve, Fig. 184. Repeat this process on the other side, moving the center B with the pencil from D to E, and the curve will be drawn; then cut the curved side to the line drawn, and the camber slip will be completed. To prove the camber slip, lay it down and mark all round it, then reverse it, and if the camber slip coincides with the lines drawn by it, it will be correct. In using the camber slip always work from a center line.

The next consideration is what amount of skewback should be given to the camber arch. By the old system the opening was taken as a radius and a line cut upon the center line as a radial point for the skewback; but this has been found to give too great a skewback

and becomes a source of weakness. The proof of this is as follows: First considered as a wedge, sustaining a vertical thrust or load. If a wedge were made too flat, when driven home the ends would become bruised and split. Again, let it be supposed that the camber arch is taken out of the segment, or let it be considered that behind each camber there is an invisible segment; then, as far as strength is concerned, the more of the segment contained in the camber, the stronger the arch; experience shows that the longer the radius, the less the rise, or the flatter the segment, and hence the more of it in the camber. The less acute skewback, if produced to meet a center line, will give the desired longer radius. Therefore a good datum to work to, as a general rule, is to give each skewback 1 in. fall for every foot of opening, when the arch is a foot upon the face.

To Set Out the Arch.—Opening, 3 ft.; face, 14 in., Fig. 185. Draw the usual base line, with a center line perpendicular to it; set out the opening AB, half each side of the center line CF. Then, with the center of the camber slip upon the center line, and the edge just coming out at the points A and B, draw the camber or curved line.

Then to obtain the skewback. At A and B erect faint perpendiculars, and upon these lines measure, from the base line upwards, distances of 12 in. and 14 in.; take square lines to the left of A and right of B, and upon these lines at the 12-in. height measure off 3 in., the allowance for an arch 12-in. face and 3-ft. opening; then from A and B, through the outer points of the 3-in. lines draw the skewbacks indefinitely. These skewbacks would answer for any depth of face for this size opening. Now take a point upon the

center line, 14 in. up from the base line, place the center of the camber slip upon this point, the curved edge at the same time passing through the two 14-in. points upon the perpendiculars erected at A and B, and while in this position draw the outer or extrados line. Prick over the courses upon this line, as in other arches, starting with the key and working out to the skewback. If it were possible to produce the skewback downwards to meet the center line, then this point might be treated as the radius point wherewith to fill in the approximate key. But should this not be practicable, the number of courses taken upon the extrados line, by reducing the distance taken in the dividers, will have to be pricked over on the intrados line, taking care, at the same time, to have an equal proportion on each side of the center line. Having pricked over the top and bottom lines accurately, draw in the approximate key, but producing the line to the right of the center line, both above and below the arch. Call this produced line DE. Now, to procure the approximate template; as before, prepare a piece of ½-in. board, 3¼ in. wide and 18 in. long, both sides planed and one edge shot. Let the shot edge be exactly placed against the left-hand line forming the key, and, with a long straight-edge placed over the board, the edge coinciding with the produced line DE, mark the template. Cut and shoot it accurately, and traverse as before. Having obtained the template, fill in the courses, and fix the cutting mark. It has already been seen that in the semi and segment the courses have been equal in length, and the bevels alike, but in the camber the bevel and length will differ in each course; the longer bevel and length being in No. 1, and the shorter in the key. An illus-

tration of the treatment of No. 1 course will serve for all the courses. No. 1 course is the first course upon the skewback. Place the template with its bed side upon the right-hand skewback line, and the cutting mark upon the camber line. Then, where the edges of the template touch the camber lines, both top and bottom and on both edges make pencil marks. One mark (the cutting mark, it will be remembered) is already made. Square these marks upon the edges, and connect the two top and the two bottom across the face of the template; this will give the length of the course upon the cutting edge, and the bevels both bottom and top. Serve each course in the same way, and number their bevels upon the template. The arch is 14 in. on the face; it will therefore be filled in as 8-in. stretcher, 2-in. closer, and 4-in. header, in one course, and 4-in., 2-in., and 8 in., in the next, and so on, as before, keying in with a stretcher towards the soffit. The skewback will be treated as in the segment, and all other operations in setting, etc., will be the same. Great care should be taken in grouting in this arch, as it is one of the weakest in construction.

It must be remembered, in cutting this arch, that the different bevels have to be taken off and marked "right" and "left," upon the bottom of the box, as was done in the case of the one bevel in the segment arch.

Moulded Camber (Fig. 186).—The moulded camber should be treated similarly to the moulded segment, the outside line of moulding being drawn in with the camber slip, parallel to the soffit, meeting the outside line of moulding on the reveal and forming the miter. The skewback must be taken extra to the moulding, or, in other words, it must be drawn from the outside

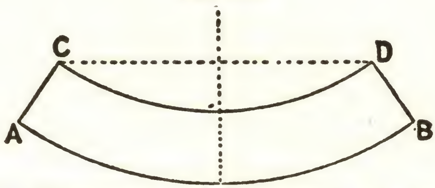
point of the miter, so that if a $2\frac{1}{4}$-in. moulding be used in a 3-ft. opening, with an arch 12 in. on the face. the top point of the skewback would fall $5\frac{1}{4}$ in. away from the reveal. The shoe mould, etc., would be obtained as in the segment arch.

Camber on Circle.—Arches circular on plan are not to be recommended, as being of weak construction. But where it becomes necessary to use them, they should be strengthened by means of an iron bar bent to the shape.

The mode of setting out this arch and obtaining the template is very simple. Let Fig. 187 be the plan of the sweep to be covered by a camber arch, of which AB and CD are the outer and inner faces respectively. Develop AB by pricking it over with compasses, or bending a thin lath round the curve and bringing it out as the straight opening EF. Upon EF construct the camber arch in the ordinary way (Fig. 188), and produce the lines of skewbacks, bringing them down indefinitely below the soffit or base line. Next develop the inside line CD of the plan in a similar manner to AB, cutting off its actual length on a rod; then lay the rod in between the skewbacks which are produced below the soffit, till, while keeping it parallel with the base line, it accurately fills in between the skewback lines. Now, with the rod in this position, draw a line which may be termed a sub-base line, and draw the camber line upon it. Next procure the template as already directed, taking care that it be long enough, not only for the ordinary arch, but also to cover the bottom or sub-camber line. Having got the bevels, cutting mark, etc., while the latter is upon the soffit line proper make another cutting mark also upon the bottom soffit line, and the template will be ready for a camber on circle.

When cutting the arch, the upper cutting mark must be used for the face of the arch-brick, while keeping it at the soffit, and the lower cutting mark will be used for the back of the brick, while keeping it in a similar position. By cutting this brick, the student will learn how to prepare the radiating box, one side of which will be higher than the other, according to which side of the arch is being cut. Or, in other words, let it be

Fig. 187.



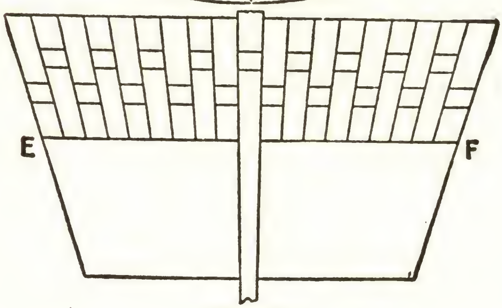


Fig. 188.

granted that the left, or leading hand of the arch, is the one to be radiated. Then, having drawn a square line across the bottom, and parallel to the tail of the box, with the face of the brick turned to the body, and the soffit towards the right hand, prepare the box by placing the *upper* cutting mark of the template against the body, and the *lower* one of the other side, to this line.

Should the curve be very sharp, it would cause the arch, if left after the above operations, to appear, on the face, as a series of short lines. To avoid this a pair of moulds 10 in. long, having the same sweep as the plan of the arch struck upon them, and 4½ in. only at their widest point, should be prepared. Each course, being laid in between these moulds according to the angles their beds make with the base line (for instance, the key-brick will lie at right angles between the curved sides), would, when cut, receive the same curve as the plan, Fig. 188. It must be borne in mind, when putting in the skewbacks, that they are radii of the same sweep.

Should the face of this or any arch be 18 in. deep, then the bonding will be as in Fig. 190.

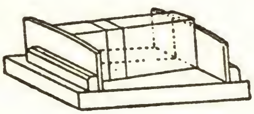


Fig. 189.

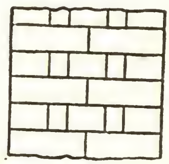


Fig. 190.

It will be noticed that the skewback of the 12-in. segment, Fig. 179, does not come out to the top of the course, making it necessary to put in a small piece of brick; and again, that the 14-in. camber, Fig. 186, is not in depth the multiple of a brick course, necessitating the cutting of an inch course over the arch.

To do away with this cutting, arches in these and similar cases may, while maintaining the same bonding on the face, be increased in depth, care being taken that the proportion between the stretcher, header, and closer is relatively the same. Thus, by

dividing the 15 in. in the latter case into seven (the number of closers in a stretcher, header and closer combined), then taking four of these for a stretcher, and two for a header, etc., the stretcher will be found to measure $8\frac{4}{7}$ in., the header $4\frac{2}{7}$ in., and the closer $2\frac{1}{7}$ in.

Equilateral or Gothic arch (Fig. 191).—Opening, 3 ft.; face, 9 in. Draw an indefinite base line, upon it erect a perpendicular center line, and set out the opening AB half each side of it. With the point of the compasses at A, and the pencil at B, draw the curve or

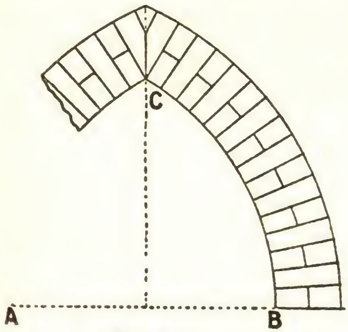


Fig. 191.

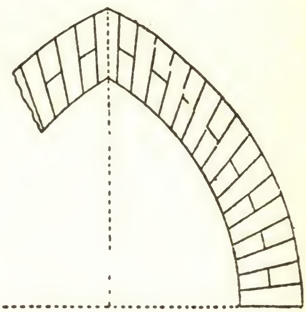


Fig. 192.

half-intrados BC; then with the point at B and pencil at A, draw the other half AC. With the same radius points, and the compasses extended to 3 ft. 9 in., describe the outer line or extrados. When set out properly, this arch, unlike all other arches, has no key-brick, but a joint in the center. It will therefore be necessary, when pricking over, to allow half a course on each side of the center line, as though providing for a key-brick. If lines be drawn from A and B to C, it will be seen that each half of the arch is really a segment, and the template will be obtained in the

same way, only, where the courses meet on the center joint, these extra long bevels thus formed will have to be taken from the drawing and marked on the template.

The above is not only the correct method for setting out the Gothic arch, but is also the strongest, as the courses are normals to the curve. But many object to keying, as it is called, with a joint, and insist upon having a key-brick. In the latter case (Fig. 192), the arch has to be set out, as all other arches, starting with half a course each side of the center line, and then

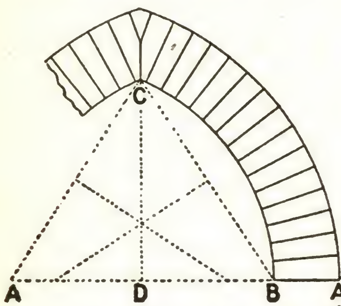


Fig. 193.

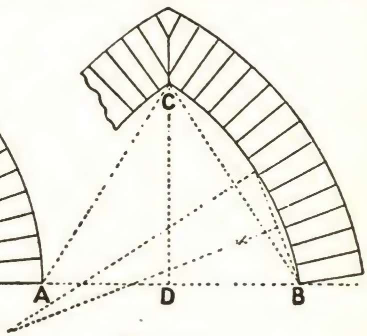


Fig. 194.

pricking over to the springing. The approximate key, which is cut as a bird's mouth, is then filled in from the center of the base line, and the approximate template obtained and traversed until it is accurate. The courses are then filled in with the latter. Under these new conditions, the courses, not being normals to the curve, will all differ in length and bevel. These will be obtained and marked on the template, in the same way as in the camber (Fig. 185).

The Modified Gothic (Fig. 193).—When the equilateral arch has to be reduced in height, by remembering that

the two sides are two segments only, the setting out becomes very clear. Again, taking the 3-ft. opening and 9-in. face, set out the base and center lines and the opening AB. Upon the center line set up the reduced height DC; join AC and CB. Bisect AC and CB with lines square to them, and produce to the base line. Where these meet will be the radial points from which to fill in the sides, the template being obtained as in the equilateral arch (Fig. 191). This, like the Gothic arch, may be filled in from the center of the base line, forming a key-brick, the lengths and bevels differing for each course.

Lastly, should the curves on AC and CB need modifying (Fig. 194), these may be brought down by treating them as segmental arches, constructing the base line, and marking the height of the curve upon the center line. Mouldings on these arches are a very simple matter, being treated, when filled in from the radial point, as the segment, and from the center, as the camber arch. In neither case is there the difficulty of the miter to meet.

The Elliptical Arch.—There is no curve in arch cutting that requires more care than the ellipse, and there is no arch in which faulty setting out, or a cripple, as it is termed, is more easily detected, especially by the trained eye. First, let it be quite understood that it is impossible to set out the ellipse by means of the compasses, though a very near approach may be obtained, when the rise has not to be taken into consideration, by the following methods:

Case 1. Fig. 195; opening 3 ft.; face 9 in.—Lay down the base line with a center line drawn at right angles above and below it indefinitely and the opening AB half each side, as before. Divide the opening AB

into four parts in the points C, D, E. With the point of the compasses at C, and the pencil at A, describe an arc; then, with the same distance in the compasses, but with the point A, cut this arc in F. Repeat this on the other side of the opening, and again cutting this arc in F. Through F and C, and F and E, draw lines meeting at the center line in G, and extended indefinitely above F. Then, with the point of the compasses at G and extended to F, describe the remainder of the curve, or intrados, from F to F. Now, going back to C, and the pencil extended 9 in. beyond A, describe the extrados terminating at the line FG. Repeat this on the other side of the opening. Then, with the point at G, and the pencil extended, draw the topmost part of the extrados. It will not be apparent that in between the lines GF there is a segment arch, the template for which will be obtained as in that arch; and that the other two portions are parts of a semicircular arch, and again the template will be obtained as for the latter arch. This is the strongest method of filling in, but the appearance of having two distinct shapes of bricks upon the

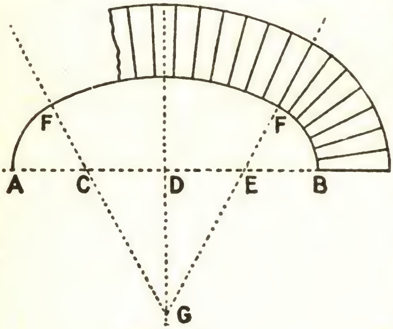


Fig. 195.

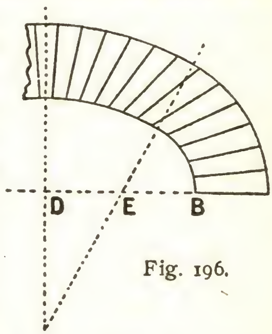


Fig. 196.

face is certainly objectionable. The difficulty may be overcome by filling in the arch the same as the camber, or by pricking over the extrados and filling in from the center of the base line for the approximate key. The bevels and lengths, of course, will differ, but the bricks will be alike on the face (Fig. 196).

Case 2. Fig. 197.—Another method of setting out by means of the compasses, with a given rise, the height of the rise bearing a liberal proportion to the opening. Set out the 3-ft. opening as before, calling it AB, and the 14-in. rise CD. Join DB; cut off CD from CB in the point *d*; take the remainder *d*B, and cut off D*b* from DB in the point *b*. Taking any distance in the compasses greater than half B*b*, and with the point first at *b*, then at B describe arcs cutting each other above and below *b*B. Through these intersections draw a line cutting the base line in the point E and the center line in the point F; then measure from A, fixing a point, G, upon the base line similar to E. Then E, F, G, will be the radial points from which to draw the arch as before.

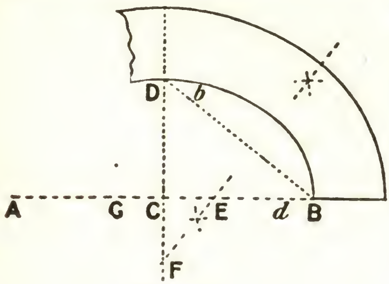


Fig. 197.

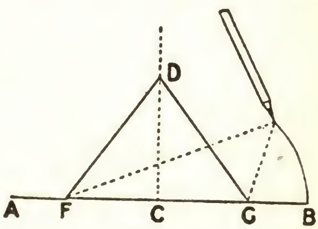


Fig. 198.

Case 3.—Fig. 198 is the string method, answering

very well for rough elliptical arches which have to be covered with plaster. Set out the opening, or major axis, AB, and the center, or half minor axis, CD. Taking the distance CA in the compasses, with the point at D, cut the base line at F and G. Then, having fixed pins at F, D, G, tie the end of a piece of string or thin wire at F, pass it round D, and tie at G. Remove the pin D, insert a pencil in the loop, and, with the string or wire extended as far as it will go, describe the curve.

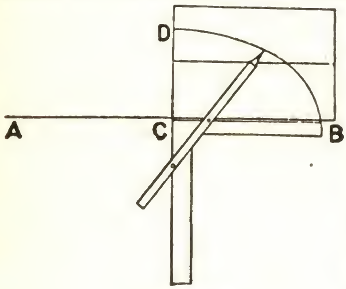


Fig. 199.

Case 4.—Neither of the above, though useful in their way, can be compared to the trammel, which is the best practical method to be recommended to brick layers. (Figs. 199 and 200).

Set out the opening AB upon the base line half each side of the center line CD, which will be drawn indefinitely below as well as above the base line. Prepare a square, the sides being about 2-in. wide and ½-in. thick, with a slight bevel taken off the under side of the outer edges; fix the square, the edge of one side coinciding with the center line, but below the base line, and the other with the right hand, and answering to the half of the base line. Next take a rod (which will be known as a trammel rod) with fixed pencil point;

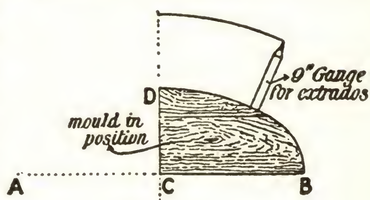


Fig. 200.

measuring along the rod from the pencil point, fix a screw, with the head downwards, at a distance equal to the rise CD. Again measuring from the pencil point, fix a similar screw equal to the distance CB, i.e , half the opening. Now take some thin boarding, kept together by ledges, equal to rather more than half the opening in length, and more than the height of the rise in width, with the bottom and left-end edges answering to the right-hand side of the base and center lines, shot true and square to each other. Fix the mould in position, with the bottom and end edges coinciding with the center and right-hand half of the base lines. Then, with the trammel rod, the head of one screw working horizontally under the bevel along the top edge of the square, and the other vertically up the square, describe half the soffit upon the roughly prepared mould, which should be properly and truly cut to the curve. This may be termed the master mould. Practice only will give perfection in striking this curve.

It is impossible to attach too much importance to the use of the master mould. The brick-cutter should set out his work to it, and also take the tickings upon it for the center; the carpenter should use it as his mould for making the center; and then it should be sent to the joiner's shop, for the purpose of setting out the curve for the head of the frame. Lamentable results have occurred through these three trades working independently.

In setting out the arch, Fig. 200, the mould should be fixed in position, the bottom of it to the base line and the end to the center line; then, having drawn the intrados line, a gauge the required depth of the face should be cut, and while one end is worked round the

master mould, the other, having a pencil attached, will describe the other curve, or extrados. The template may then be obtained and the arch filled in as before. It will be seen from the description that theory differs in many points from practice. The extrados in theory is not parallel to the intrados. In theory also, each face course, or voussoir, being normals to the curve, would differ in shape, and, though not quite impossible, would be most expensive in practice.

In setting out elliptical arches consisting of alternate blocks of brick and stone, the divisions should be in

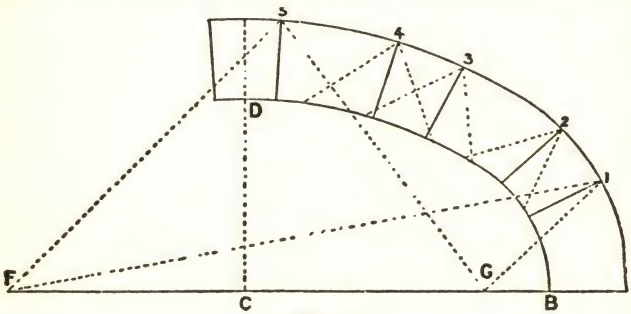


Fig. 201.

the proportion of 5 to 3 or 6 to 4 respectively; and in large arches each division should be set out normal to the curve, and separate templates obtained for each block of brick and stone. For instance, take an arch for a 7-ft. opening, 2-ft. 3-in. rise, 12-in. on the face (Fig. 201), to be filled in with red bricks and cut stone, but starting with red brick and keying in with stone. Set out the opening in either of the ways as shown, then upon the extrados, set out the courses of brick and stone, either as 5 to 3 or 6 to 4, whichever comes in most conveniently. In this case 5 and 3 appear to work in the best; so, starting with the key, tick in

stone equal to three courses of brick, next to this five courses of brick, then stone, and so on. Number the divisions 1, 2, 3, 4, 5. Now find the foci to the outer curve. This is done by taking the distance CB in the compasses, placing the point of it at D, and cutting the base line in F and G. From tick 1 on the extrados draw lines to F and G, bisect the angle thus formed, and the bisector will be one of the joints required. Serve the other joints in the same way, and then get the templates for each division of brick.

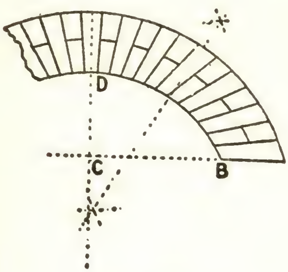


Fig. 202.

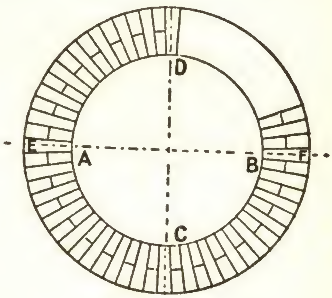


Fig. 203.

It would be as well, too, in large elliptical arches, say for 12-ft. openings, built of *brick* only, to make divisions in this manner, and obtain templates for each; for only those who have anything to do with these arches know the difficulty of obtaining one or even two templates for a very large ellipse.

The scheme arch, Fig. 202, is one which, while starting off a level bed, has a less rise than a semicircular arch. Let AB be the opening, with the center line CD, CD being also the 12-in. rise. Obtain the curve ADB as if for a segment, then extend the compasses for the 9-in. extrados, carrying it down to the

springing line. Prick over the extrados, putting in the approximate key from the center C, and traversing the template until it comes out to the springing line. It will be noticed that the courses differ somewhat in bevel and length and must be taken off as in the camber.

Bull's Eye Arch, Fig. 203.—The curve of this arch is a complete circle, AB and CD being the base and center lines crossing each other at right angles, the curve and face being drawn and the template obtained as described in the construction of the semi-arch; the only difference is in the disposition of the two side key-bricks, which are placed as E and F.

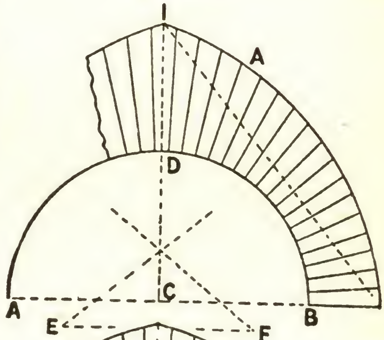
The above are the principal arches, but there are various others which are often used as a mixture of two of the foregoing, and are as follows:

The Semi-Gothic, Fig. 204, has a semicircular intrados, but a Gothic extrados. Let AB be a 3-ft. opening, with CD as the center line. Set out the ordinary semi; then upon the base line beyond A and B measure off the face, say 9 in., and with either of the methods described for drawing the Gothic, proceed to draw the extrados according to the height required. In this instance the radius is taken from E and F. It will now be necessary to prick over the soffit of the arch to get the approximate key, putting in a trial key first to ascertain how the brick will hold out towards the top. Having fixed the approximate key, get the template as previously shown. The soffit bevels will be the ordinary semi-bevel, but the extrados bevels will all differ as will the length of the courses. When drawing the arch only, fill in from the center C.

The Ellipse Gothic Arch, Figs. 204 and 206.—Let AB be the 3-ft. opening, 1 ft. 6 in. of which is each side

of the center line, and rise CD. Divide AB into three equal parts in E and F. From E and F, with the radius FB and EA, describe arcs as in the ellipse struck with the compasses, terminating at the points H and G. Join HD and GD by faint lines. From H and G through F and E draw faint, indefinite lines. Bisect HD and GD, and produce lines square to these. The points in which these latter lines meet the lines passing through HF and GE will be the radial points for the top part of the arch. The extrados will be drawn by extending the compasses from the radial points by which the intrados is struck. Two templates will be used, one answering for the two arcs, and the other for the two segmental portions of the arch.

Fig. 204.



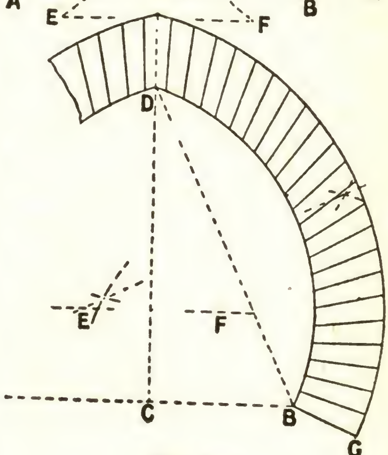
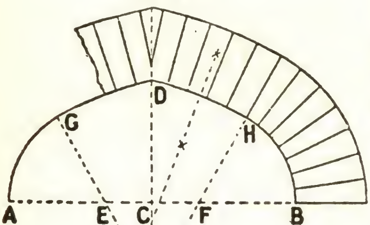


Fig. 205.

The Horse-Shoe or Moorish Arch, Fig. 205.—This is an arch but very seldom seen, but it is well that the practical man should be acquainted with it. Set out the

3-ft. opening AB, and the center line and 3-ft. 3-in. rise CD. Join AD and BD; bisect DB; set up the rise and describe the curve as in the ordinary segmental arch; from the radial point E, through B, draw the skewback BG; measure the face upon BG; extend the compasses, and draw the extrados, terminating at the opposite end of G upon the produced center line CD. Treat the other side of the arch in the same way. Although filling in the arch as though there were two segments is far stronger, still a better appearance is gained by pricking over the extrados, filling in the bird's-mouth key from a point made by the skewback being produced to cut the center line, and then traversing the template, and treating the arch as a scheme. The courses will have different bevels, and will be slightly different in length.

Fig. 206.



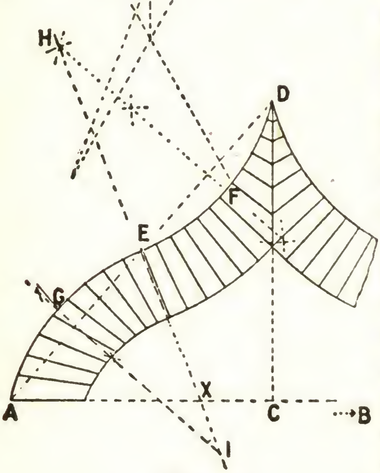


Fig. 207.

The Ogee, Fig. 207, is another peculiar arch, weak in construction, and to be used only as an ornamental feature. Let AB be out to out of extrados, and CD the rise of the same. Draw a line from A to D, and

bisect it in E. Bisect DE, producing the center line both above and below it, as in the segment, and the same with EA. Upon DE set up the rise upon that part of the center line pointing to DB, and upon EA set up the rise upon the opposite side. Then describe the curves DFE, EGA, in the ordinary way. From the point H, by extending the compasses 9 in., put in that portion of the intrados from the line EI to the center line CD, and from the point I, by decreasing the distance in the compasses 9 in., draw in the part of the intrados from EI to the base line AB. Deal with the bottom portion of the ogee as a scheme, by getting the shape of the template from the point X, made by EI cutting the base line; and the top part as a segment, obtaining the template from the point H. Traverse the templates, accurately fill in the courses, and mark the bevels and lengths.

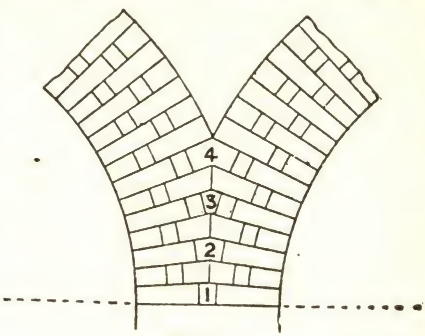


Fig. 208.

Arches Springing from the Same Pier, but Differing in Size.—It frequently occurs—in bays, for instance—that while there is one large opening in the middle, there may be a smaller one upon one or each side of it, and that one skewback of the large and one of the smaller arch will be adjacent to each other upon the same pier. Adhering to the rules for skewback, the latter will be at different inclinations, thus presenting a most unsightly appearance. To overcome difficulties such

as these must be left to the judgment of the practical man. As an example, two camber arches, one for a 4-ft. and the other for a 2-ft. opening, both 12 in. on the face, have skewbacks of 4 in. and 2 in. respectively upon the same pier. Here an average should be struck, giving each arch a skewback of 3 in.

As another distance, let there be two segment arches, one opening 4 ft. and the other 2 ft., both of the same rise. In this case the smaller arch should be sacrificed to the larger, keeping the same rise in both, but giving the smaller the same skewback as the larger, thus converting it into a scheme.

Intersection of Haunches.—When two arches spring from the same pier, and the depth of their combined faces more than equals the width of the pier, then a proper intersection of their haunches should be arranged. In Fig. 208, two semicircular arches, 14 in. upon the face, spring from an 18-in. pier. The bond on the faces is kept, as far as possible, down to the springing. But where the outer lines of the haunches meet, the intersection is alternated with saddle-bricks, 1, 2, 3, 4, and upright joints. Moulds will have to be procured with which to cut the saddle-bricks.

It will be seen that it is impossible to get the saddle-brick No. 4 out of a brick flat, but it may be obtained by placing the brick on edge, which in this and other similar cases is permissible, the difference being made up by filling in at the back

THE NICHE

For years past, to cut and set a niche ha been considered a clever achievement indeed; but, as a matter of fact, it is really not so difficult as it appears. By careful attention to directions and rules here given,

any practical man of ordinary ability will be able to accomplish it.

Semicircular Niche.—That is to say, semicircular both on plan and on elevation, Fig. 209. First to set out and cut the body, taking the opening as 3 ft. Draw the opening AB, and at right angles to it the center line DC. From the center D, with DA as radius, describe the semi ACB, then extending the compasses 4½ in., put the 4½-in. thickness of work in the body of the niche. Taking 2¼ in., or, if necessary, 2¼ in. full in the compasses, prick over from C to A, but on the outer curve, as many 2¼ in. as will make

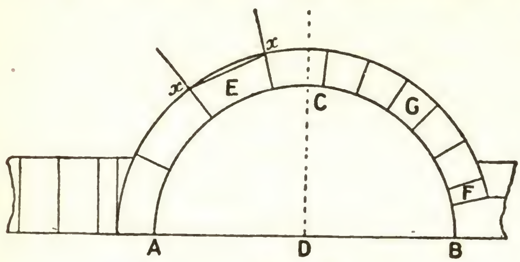


Fig. 209.

Fig. 210.

an even number of stretchers and a half, so that half a stretcher shall come each side of the center line. Then with 2¼ in. again in the compasses, prick over the side CB, putting in the headers and closers to bond with the stretchers on the side CA. The first header at B will appear as a stretcher upon the face, and the first stretcher at A as a header, having a closer next it. Moulds must now be cut for the stretcher acting as face header at A, for the stretcher E, for the headers acting as face stretcher at B, for the closer F, and the bat headers G.

The mode of preparing the moulds is as follows:

Taking the stretcher E as an example, produce the joints XX, take two pieces of board, 10 × 4¾ × ½ in., screwed together, and having one edge shot. Fix the boards down over E with the shot edge from X to X. With the radius DC, and from the center D, describe upon them the inner curve. Then with a straight-edge from D to the produced lines X, draw in the radii, but allowing rather more than $\frac{1}{32}$ in. for joint and tinned edges to the mould. Have the mould accurately cut and fitted to the lines, and after tinning they will be ready for use (Fig. 210). They are fixed in a box with the edges which were placed at XX downwards. The bricks are prepared by being properly bedded, and one face roughly squared; they are placed in the cutting box, two at a time, the roughly squared face downwards, with the beds tight up to the moulds and fixed. The two ends and two faces are sawed completely over, and finished with a file. Then, having been tested for accuracy by squaring from the bed to face and ends, they are brought to thickness, and are then ready for the body of the niche. The other moulds and bricks will be prepared in the same way. In setting, the plumb rule, level, and a hand mould answering to the semi ACB, are all that will be required to keep the work true. It should also be tried occasion-

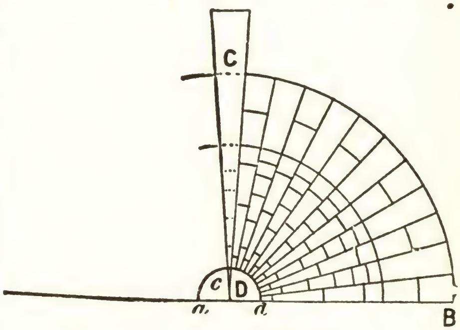


Fig. 211.

ally, to see that the work is kept to the proper height.

Next to set out and cut the head or hood, Fig. 211. Draw the base line AB, and set up the center line DC. With the point of the compasses at D, and the radius DB, describe the extrados ACB. Then, with the compasses decreased, draw in the 9-in. face. Prick over the extrados as directed in other arches, putting in the approximate key, and obtain the template, which, unlike that for other arches, will extend from above the outer face to the point D. Having obtained the accurate template, place it in position as the key, and with its point at D. Then with the point of the compasses at D, and the pencil extended to where the

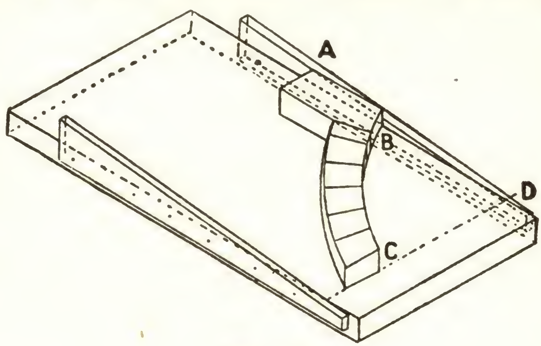


Fig. 212.

template becomes ½ in. in width, draw the boss *acd*. Fill in the arch and hood with the template, letting the courses extend from and include the face, home to the boss. Obtain the bevel and the cutting mark as though for the ordinary semi or face arch.

Now take the courses as prepared for the body of the niche; half a course will answer for the right-hand side of the arch, and half for the left; but instead of

squaring from the bed to the inside face, use the arch bevel, and bevel from the bed to the face, rubbing the bed to make it answer the bevel, and also the squared ends.

The radiating box is now necessary, and is prepared as follows: Make a stout bottom 2 in. in thickness, in length about 2 ft. 6 in., i.e., somewhat longer than the template, the width being 2 ft. 3 in., or DC of the body plus 4½ in. thickness of work, with a little to clear. For the sides of the box, take two pieces of board 2 ft. 6 in. long and 4 in. wide, properly shot and

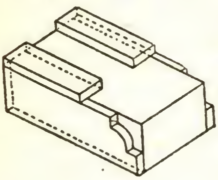


Fig. 213.

tinned on the top edge. Upon the face of one of these boards tack the template, with the cutting edge of the latter flush with the tinned edge of the former. In this position the prepared side

Fig. 214.

will project below the template, and with the bed of the template resting upon the bed of the bottom of the box. Securely nail it there. Scribe the cutting mark upon the tinned edge and remove the template. Go through the same process for the other side, taking care that the cutting marks on both sides are immediately over a line squared across the tail of the box, and the radiating box will be complete, (Fig. 212).

Mode of Cutting.—Of the prepared courses, place the brick which answers to the face stretcher, or long header B of the body, in the box, with the face to the right-hand or A side of the box, and the soffit to the cutting mark, and, measuring away from the soffit of this brick at the cutting mark, and along the side of the box for the radial point D, describe the quadrant BCD. Place the remainder of the course to this

curve; fix it down; then, keeping the wire saw at right angles to the sides of the box, saw the course right over, and keeping the file in the same position, properly finish it, working away from the edge so as to preserve the arris. With the opposite hand go through a similar proceeding, and the same with the next courses. Cut the solid boss, and the hood will be ready for fixing.

Fixing or Setting.—A solid head or turning piece is not at all necessary. In fact, when using this, the most important part of the work, which when finished will be seen, has to be guessed at while fixing. Instead of this, a hollow semicircular rib to fit the head or body should be made, having an outside rib only, about ½ in. thick, so that while the setting proceeds the inside may be seen. Upon this will be marked from the drawing the soffit joints of the face arch, so as to ensure that the work is rising properly. Then, starting upon each side, proceed to fix the work. If the front turning piece should be found insufficient when nearing the key, then a lesser but similar semicircular mould may be used further in. Finally properly grout in the work with Portland cement.

The Elliptical Niche.—This is similar to the semicircular but elliptical upon plan. Taking the opening as 3 ft., set out the body upon plan, using the trammel method. Fill in the stretching and heading courses as before, but in this case pricking over the outer and inner curves for the proper shape of the bricks, and obtain the moulds as already directed. The head will be semicircular and, although the body is elliptical, there will be but one bevel, the courses being placed in the box, not to a quadrant, but to the shape of half the elliptical curve.

Moulded Soffit to Niches.—It will be readily seen that, should the edges of the opening and the soffit of the arch be moulded, this would be cut on the moulds answering to the bricks A and B, Fig. 209, and would be cut upon these bricks at the same time that they were being shaped for the niche.

LABELS TO ARCHES AND NICHES

Moulded labels going over camber arches need very little description, being merely moulded bricks as stretchers or headers set over the arch. But when a label has to be fixed over a semicircular or segmental arch or niche, it is very evident that if straight moulded bricks were run over such arches, their beds would appear as a series of short straight lines, looking most unsightly. It is, therefore, apparent that a curve struck with the same radius with which the arch was set out must be run on each, and they will also have to be cut to a radial template, in a similar way to an arch; the course, 3 in. or 4½ in. in depth, as the case may be, being set on the top of the arch. If it be 3 in. deep, then the pricking over on the extrados will be 4½ in.

The bricks will be moulded one at a time. The mode of doing this is to use a pair of clip moulds, which will hang one on each side of the brick (Fig. 213), placed in the box, bed or soffit upwards; then, after sawing and roughly filling it, the brick should be finished off with a piece of stout sheet iron having a convex curve of the same sweep as the extrados of the arch worked upon it (Fig. 214). By keeping the sheet iron upright while using it, the curve will be worked not only upon the soffit of the brick, but throughout the moulding. After the label has been set, sufficient

substance will have been left upon the top edge of the label to admit of its being worked off with a hand-stone, either to the eye or to a prepared mould.

THE ORIEL WINDOW

The oriel window, whether in stone or brick, is a most artistic feature in a building. Stone lends itself more readily to the safe carrying out of this work than brick. When built of the latter material, a frame of light ironwork treated with oil or painted to prevent oxidation may be constructed, with the ends either built into the main wall, or bolted firmly to the joists. But, according to circumstances, so the mode of keeping the work in its place must be determined by the practical man.

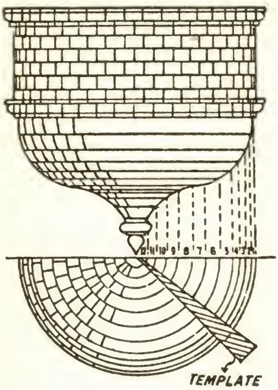


Fig. 215.

To cut the oriel, set it up in elevation equally each side of a center line. Now, if the courses are to be equal in thickness, the center line, or height, must be divided off into 3-in. courses. The courses will then appear upon the curve as unequal in thickness. But if they are to appear equal in thickness, prick round the curve at 3 in. The courses will then really be unequal (Fig. 215, in which the setting out is according to the latter system). Set out a pair of moulds for

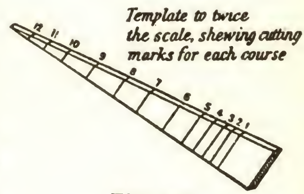


Fig. 216.

each course, with the curve worked upon each. Draw a horizontal line beneath the elevation, and from each course upon the curvature of the latter, drop perpendiculars to the horizontal line. Then from the center to each of these points will be the radius with which to draw the plan of each course. Prick round the outer curve and obtain the template, which must reach from the outer line to the radial point. Different cutting marks will be placed upon the template for each course, working from the outer one towards the radial point (Fig. 216). From this plan it will be seen how many bricks will be wanted for each course. To cut the work, bed the bricks, square one face, and mould and take to thickness at the same time. Then place them in the radial box at the cutting mark to which they belong, and after sawing and finishing with the file, they are ready for setting.

In setting, take care to half-bond the courses and properly flush up with Portland cement An inverse mould fixed at each end, and ribs or moulds answering to different courses upon plan, will be found useful to test the work as it proceeds.

MEASUREMENT OF BRICKWORK, POINTING, ETC.

Most bricklayers know how to use the foot rule in measuring ordinary work, but, having attained the measurement, the difficulty arises as to how to square or cube the quantities thus obtained. Another difficulty also met with is how to take the measurement of awkward shapes, e.g., gables, arches, etc. This chapter, therefore, is intended to help those who have no knowledge whatever of the subject.

In the building trades, measurements are taken as foot run, foot super, or square and foot cube.

Foot Run relates to length only; for instance, drains, tile-creasing, cutting under 6-in. wide over circular arches, cement fillets, etc., are taken and priced at the foot rule. In this there are 12 in. to a foot, and 3 ft. to a yard.

Foot Super, or Square.—Here length is multiplied by width or height; a paved floor, so many feet long by so many feet wide, will have so many feet super, or square, of paving. In a square foot there are 144 square inches. To make sure that this is so, draw a square 12 in. long by 12 in. wide, and divide up into inches; it will be seen that there are 144. But in the building trades, both with square and cube measurements, twelfths of feet are reckoned upon. So 6 square feet 72 square inches would be written 6′ 6″ super. There are also 9 square feet in a square yard. This may be proven by laying down a square 3 ft. long by 3 ft. wide, and dividing into squares 12 in. by 12 in., when nine squares will have been formed Foot super is used in measuring facings, paving, tiling, etc.

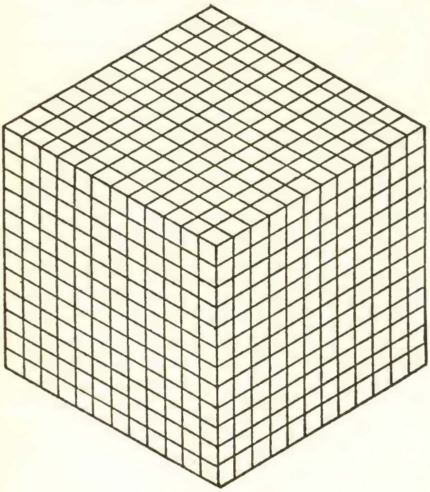


Fig. 217.

Cube measurement is length × (multiplied by) thickness × depth or height. Thus, in finding the cubic

contents of an 18-in. square pier, say 6 ft. high, it would be stated as $6' \times 1'\,6'' \times 1'\,6''$. In the cubic foot it will be seen (Fig. 217) that there are 1728 cubic inches. That is to say, that 1728 wooden cubes, $1 \times 1 \times 1$ in. may be built up to form a cube 12 in. long, 12 in. broad, and 12 in. deep. Here again, instead of reckoning 1728 inches, the cubic foot is divided into twelve cubes, and 6 cubic feet 864 cubic inches is written as $6'\,6''$ cube. There are 27 cubic feet in a cubic yard, as may be seen by making twenty-seven cubes $12 \times 12 \times 12$ in. and piling them together to form a cube $3 \times 3 \times 3$ ft. Cubic measurement is used for excavations, concrete, etc.

Before squaring dimensions, a perfect mastery of the multiplication tables up to 12 times is necessary. A thorough knowledge of these tables will also be sufficient for division when needed. Thus, knowing that 12 times 9 are 108, then 12 into 108 equals 9, and 12 into 112 equals 9 and 4 over, or 9 into 108 equals 12, and 9 into 112 equals 12 and 4 over, etc. A constant practice in this will be invaluable in squaring dimensions.

There are several arithmetical methods of squaring dimensions, but for those who are not expert it would be better to adopt one system only. An easy and accurate method is that known as cross multiplication, or duodecimals. By duodecimal is meant multiplication by twelves. Take as an instance 5 ft. 7 in. $\times$ 2 ft. 4 in., or, as it is written

$$
\begin{array}{rrr}
5' & 7'' & \\
2' & 4'' & \\
\hline
11' & 2'' & \\
1' & 10'' & 4'' \\
\hline
13' & 0'' & 4''
\end{array}
$$

Here start to multiply 5 ft. 7 in. by the 2 ft. and say twice 7 are 14; 12 into 14 equals 1 and 2 over; place the 2 under the 4, and carry 1. Next, twice 5 are 10, and the 1 carried equals 11; place this under the 2 ft. Proceed with the multiplication by 4 in., and say 4 times 7 are 28; 12 into 28 equals 2 and 4 over; place the 4 in the line under 11 ft. 2 in., but one place to the right of the 2 in., and carry the 2. Then 4 times 5 are 20, and the 2 carried make 22; 12 into 22 equals 1 and 10 over; place the 10 under the 2 in. and 1 under 11 ft. Add these two lines, starting with the first figure to the right; so 4, with nothing added, equals 4, bring it down in its place; 10 and 2 (or 10 plus 2) are 12; 12 into 12 equals 1 and none over, place 0 under the 10, and carry 1; the 1 carried plus 1 and 11 are 13, place the 13 under the 1; and the answer will be 13 ft. Whenever in the place twice removed to the right of the feet (or where 4 appears in the last result) the figure is 6 or over, reckon this as one more to the place to the right of the feet (or where 0 appears in the last result), but when under 6 discard it. Thus, if the last answer had been 13′ 0″ 7‴ call it 13′ 1″, but being 13′ 0″ 4‴ only, it should be taken as 13′.

Cubing.—Let 6 ft. 4 in. × 2 ft. 11 in. × 3 ft. 6 in. be the dimensions, written as

$$\begin{array}{r} 6'\ 4'' \\ 2'\ 11'' \\ \underline{-3'\ 6''} \end{array}$$

Proceeding as before (see below), begin by multiplying 6 ft. 4 in. × 2 ft. and say twice 4 are 8; this cannot be divided by 12, so place it under the 11. Twice 6 are 12; place this under the 2 ft. Then multiply by the

11 in.; 11 times 4 are 44; 12 into 44 equals 3 and 8 over; place the 8 under the 12 ft. 8 in. but one place to the right of 8, and carry the 3. Then 11 times 6 are 66, and the 3 carried make 69; 12 into 69 equals 5 and 9 over. Place the 9 under the 8, the 5 under the 12, and add the two lines; 8 and 0 equals 8, write it in its place under the 8; 9 and 8 are 17, 12 into 17 equals 1 and 5 over, place the 5 under the 9 ft. and carry the 1; 1 and 5 are 6, and 12 are 18 ft., place the 18 in its proper position as feet; and the result so far is 18′ 5″ and 8″. Multiply this by 3 ft. 6 in. placing the 3 under the 18, and the 6 under the 5. As before, first multiply by the feet and say 3 times 8 equals 24; 12 into 24 equals 2; carry the 2 and place 0 in the lines under the 3 ft. 6 in., but to the right of the 6. 3 times 5 equals 15, and 2 equals 17; 12 into 17 equals 1 and 5 over; place the 5 under the 6 and carry 1. 3 times 8 are 24, and the 1 carried makes 25; place the 5 under the 3 and carry 2. 3 times 1 are 3 and 2 equals 5; place it to the left of the last 5, making 55. Then multiply by the 6 in. and say 6 times 8 are 48; 12 into 48 equals 4 and 0 over; again place the 0 under the 55′ 5″ 0, but one place to the right of the 0, and carry the 4. 6 times 5 are 30, and the 4 carried, 34; 12 into 34 equals 2 and 10 over; place the 10 under the 0 and carry 2. Then multiply 18 by 6, adding on the 2, and making 110; 12 into 110 equals 9 and 2 over, place the 2 under the 5, and the 9 under the right hand 5 of the 55. Add the two lines together; 0 coming first, bring down; 10 and 0 are 10, bring down the 10; 2 and 5 are 7, bring this down; 9 and 5 are 14, put down the 4 and carry the 1; 1 and 5 are 6, put the 6 to the left of the 4. The answer is 64′ 7″ 10″ cube or 64′ 8″ cube. Dividing this by 27, we get 2 yards 10′ 8″ cube.

6′ 4″		
2′ 11″		
12′ 8″		
5′ 9″	8″	
18′ 5″	8″	
3′ 6″		
55′ 5″	10″	
9′ 2″	10″	0″
64′ 7″	10″	0″

Timesing.—When a dimension occurs several times over, it is written thus—

$$\begin{array}{r|l} 2 & 5'\ 7'' \\ & 2'\ 4'' \end{array}$$

which means that the result of 5 ft. 7 in. × 2 ft. 4 in is to be multiplied by 2; and looking to rules given it will be seen that this is 13 ft. × 2, which is 26 ft.

Again, a quantity written thus—

$$\begin{array}{r|l} 3 \cdot 2 & 5'\ 7'' \\ & 2'\ 4'' \end{array}$$

or dotting on, it is called, means that the result of 5 ft. 7 in. × 2 ft. 4 in. is to be multiplied by 2 added to 3 or 5; and the whole result would be 65 ft.

Digging is taken at the yard cube, and depends for price upon the depth, and the distance the earth has to be wheeled or carted.

The least amount of depth of trench for a 14-in. wall, including footings and concrete, would be 2 ft. 3 in.; the width being 3 ft. 3 in. Then, taking it that the measurements of digging to trench for a 14-in. wall 20 ft. long are required, the trench itself would be 20 ft. plus (3′ 3″ − 1′ 2″) equals 22 ft. 1 in. × 3 ft. 3 in. × 2 ft. 3 in. The 2 ft. 1 in. being projection of

footings, concrete, etc., at each end; and the amount of concrete 22 ft. 1 in. × 3 ft. 3 in. × 1 ft. 3 in. These dimensions may be obtained by drawing the plan of the footings and concrete for length and width, and setting up the section for depth, as already shown on page 8.

Concrete of less thickness than 12 in. or where under pavings, etc., is taken at per yard super.

In brickwork the difficulties of measuring are somewhat greater. In some places practice is to reduce all work of 1½ bricks thick and upwards to a standard of 272 ft. super 1½ bricks thick, which is called a rod; the actual measurements being 16½ ft. × 16½ ft. × 1⅛ in., or 306.2812 cu. ft., reckoned in practice as 306 cu. ft. Walls under this thickness are generally specified with the work they entail, e.g., struck joints both sides, pointed, circular, etc. When measuring footings, for instance, multiply the average length by the average thickness, and then by the height. When taking the average thickness, first add the width of the top course to the width of the bottom course in bricks, and divide by 2; thus for a 2-brick wall, 2 plus 4 ÷ 2 equals 3. Then the average thickness will be 3 bricks, or 2 ft. 3 in. (When the bottom course is doubled, take one of these courses separately, and afterwards add.) Taking the length of the wall to be 20 ft., the average length of the footings will be 20 ft. plus (2 ft. 3 in. average thickness − 1 ft. 6 in. width of neat work) equals 20 ft. 9 in. The height of the footings. as already shown, including one course of the wall will be five courses, or 15 in., and the quantity of footings equals 20 ft. 9 in. × 1 ft. 3 in. 3 bricks thick equals 25 ft. 11 in. or 26 ft. of work 3 bricks thick. By multiplying 26 ft. by 6 (the number of half bricks in 3

bricks) and dividing by 3 (the number of half bricks in 1½ bricks), the work will be brought to the standard measurement, 26 ft. × 6 ÷ 3 = 52 ft.

In ascertaining the quantity of digging, to trenches, concrete, and footings, for a rectilineal building, much labor may be saved by taking an average. Let ABCD (Fig. 218) be the plan taken through the 3-brick wall of a building 50 ft. × 30 ft. out to out. If miter lines be drawn from A to E, B to F, C to G,

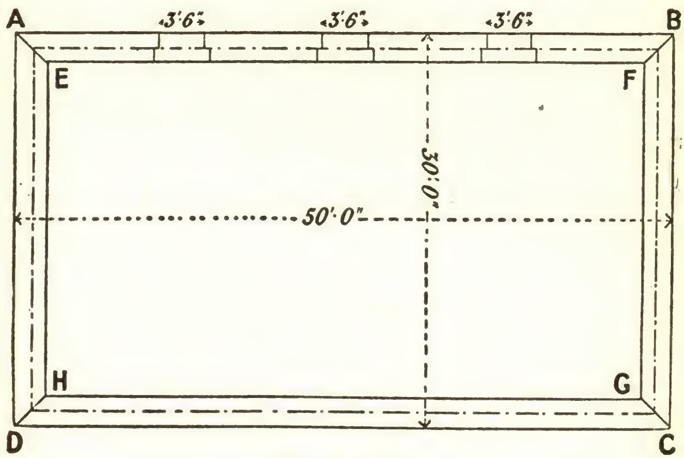


Fig. 218.

and D to H, and lines midway between the inner and outer lines, but terminating upon the miter lines, be also drawn, the average length of the walls will be found to be 2/47 ft. 9 in. and 2/27 ft. 9 in. Then the digging for trenches will be 2/47 ft. 9 in., or 151 ft. × 5 ft. 6 in. × 3 ft. 10 in., which equals 3183 ft. 7 in. cube, or 117 cu. yd. 25 cu. ft. Concrete 151 ft. × 5 ft. 6 in. × 1 ft. 10 in. equals 1522 ft. 7 in. cube or 56 cu. yd. 11 cu. ft. Footings average thickness equals (3 plus 6) ÷ 2

equals 4½ bricks; the height including one course of wall equals 1 ft. 9 in., which equals 151 ft. × 1 ft. 9 in. × (9 half bricks ÷ 3 half bricks or) 3 equals 792 ft. 9 in. or 793 ft. super of reduced work. To this will be added one of the bottom doubled courses, which equals 151 ft. × 3 in. × (12 ÷ 3 or) 4. This equals 151 ft. of reduced work, and together 793 ft. plus 151 ft. equals 944 ft. or 3 rd. 128 ft.

Brickwork is usually measured first as ordinary stock work, length by height, the thickness stated, extra per foot super being allowed for facings; and all openings, arches, etc., deducted. It is usual to measure floor by floor, starting from the footings to the under side of the ground floor joists, and so on.

Taking Fig. 218 as a guide, and supposing the quantities of the wall AB 15 ft. in height, faced with red builders and pointed, with a weather joint, and containing the three 6 ft. × 3 ft. 6 in. window openings, are required, the stock work will measure 50 ft. × 15 ft. 3 bricks thick 750 ft. × (6 ÷ 3) or 750 ft. × 2 equals 1500 ft. reduced work. But from this must be deducted (3/3 ft. 6 in. × 6 ft.) plus (3/4 ft. 3 in. × 6 ft.) 1½ bricks thick equals 139 ft. 6 in. 1500 ft. – 139 ft. 6 in., equals 1362 ft. 6 in. or 5 rd. 2 ft.

The extra for facings, including pointing, will be 50 ft. × 15 ft. super, and added to this six reveals 6 ft. × 14 in., and three soffits of arches, say, allowing for rise, 4 ft. 14 in. From this again will be deducted the superficial measurement of the three window openings; 50 ft. × 15 ft. equals 750 ft.; 6/6 ft. × 1 ft. 2 in. equals 42 ft.; 3/4 ft. × 1 ft. 2 in. equals 6 ft.; together 750 plus 42 ft. plus 6 ft. equals 798 super; deduct 3/6 ft. × 3 ft. 6 in. equals 63 ft. super; leaving 798 ft. – 63 ft. or 753 super.

Chimney Breasts.—Measure the width by the height, stating the thickness of the work; deduct the fireplace opening. The flues are taken in as if solid, pargeting to these being numbered. Ovens and coppers are also measured as solid, deducting the ash-hole only.

Arches.—The face and soffit are measured separately, and afterward added. The camber arch (Fig. 185) will serve as an example for measuring. The opening being 3 ft., but taking 12 in. as depth of face, add one skewback, making it 3 ft. 3 in. × 12 in. (depth of face), 3 ft. × 4½ in. soffit; the superficial measurement in this case will then be 4 ft. 4½ in.

For all radial arches, pass the tape round the face, midway between the intrados and extrados, arrive at the amount, and multiply by the depth of the face; then serve the soffit in a similar manner, multiplying by the depth.

Taking Fig. 176 as an example, the face is found to measure 3 ft 9 in. × 12 in. equals 3 ft. 9 in., soffit 3 ft. 2 in. × 4½ in. equals 1 ft. 2 in. and together 4 ft. 11 in.

The practical man sometimes finds a difficulty in multiplying by such awkward quantities as 6. ft. 9 in. 4½ in.; but, by a little thinking, these become quite easy.

Feet multiplied by feet will give square feet, e.g., 12 ft. × 12 ft. equals 144 ft.

Feet multiplied by inches equal twelfths of feet; e.g., 20 ft. × 6 in. equals $\frac{120}{12}$ sq. ft.; inches multiplied by inches equal square inches.

Feet multiplied by 6 in. will give half the amount multiplied; thus 12 ft. × 6 in. equals 6 ft. square.

Feet multiplied by 3 in. will give one quarter of the amount multiplied; 12 ft. × 3 in. equals 3 ft. square.

Feet multiplied by 9 in. will give the last two results

combined; 12 ft. × 9 in. equals (½ of 12) equals 6, plus (¼ of 12) equals 3, together 9 ft. square.

Feet multiplied by 4½ in. will first be taken as the last and half of that again taken, because 4½ in. is half of 9 in.

Feet multiplied by 2¼ in. would be half of the above, for the same reason.

Feet multiplied by 4 in. will give one-third of the amount multiplied, 4 in. being one-third of 12 in.

Feet multiplied by 8 in. will give twice the result of the last, 8 in. being two-thirds of 12 in.

To reduce cubic feet of brickwork to superficial feet of standard thickness, deduct one-ninth, e.g., 40 ft. × 20 ft. three bricks thick equals 1600 ft. reduced work; compare with 40 ft. × 20 ft. × 2 ft. 3 in. equals 1800 cu. ft.; take from this one-ninth of 1800 ft. or 200 ft., leaving 1600 ft. reduced work as before.

Practical men usually take pointing by the square of 100 ft. super.

To measure gables or pediments, take the central height by half the base for superficial measurement, and for brickwork according to the bricks thick.

To find the area of a circular opening, multiply the square of the diameter by 0.7854; e.g., diameter of circle, 10 ft.

10 ft. × 10 ft. equals 100 ft. × 0.7854 equals 78.54.

To measure fair cutting to a circle, multiply the diameter by 3.1416; e.g., diameter of circle, 10 ft.

10 ft. × 3.1416 equals 31.416.

For a semicircular arch, half the above, e.g., diameter of semicircular arch, including depth of face on each side, equals 10 ft. Fair cutting round the arch equals 31.416 as above for the whole, ÷ 2 equals 15.708.

In measuring brickwork over 60 ft high from the ground, it should be kept separate, and divided into heights of 20 ft., viz., 60 to 80, 80 to 100, etc. The reason for this is that the higher the work goes the more expensive it becomes to build.

Keep the following work separate:

Brickwork built overhand.

Raising on old walls, stating the height the work commenced from ground level.

Circular brickwork.

Half-brick partition walls.

Sleeper walls.

Measure hollow walls as solid.

The following work is usually taken at the yard super: Lime-whiting; pointing when not included with the facings; brick-nogging, including timbers, stating if built flat or on edge; cement floated face, stating thickness, if to falls, and if floated or troweled; all kinds of paving; wall tiling, giving full descriptions.

Work measured by the foot super: Damp-proof courses; trimmer arches; fender walls; sleeper walls; half-brick partition walls; arches generally, except gauged; facings, keeping the different kinds separate.

Work measured at per foot run: Cement filleting, cuttings under 6 in. wide, pointing flashings, cutting chases for pipes, brick on edge, and other kinds of copings.

Items numbered: Bed and point frames; setting stoves and ranges, fixing chimney pots, ventilating bricks, parget and core flues, rough relieving arches.

Hoop-iron bonding is measured at per yard run, adding 5 per cent to the length for laps, stating if tarred and sanded, and making no deductions for openings.

When finished estimating as above, add at least 7½ to 10 per cent to the whole amount for extra scaffolding, and contingencies generally. Some builders add as much as 15 or 20 per cent to estimate, but, when competition is sharp, the contractor adding this large percentage will stand a poor chance of securing the work.*

TOOLS USED BY THE BRICKLAYER AND HIS HELPERS

The tools shown in the Frontispiece (which see), figuring from 219 to 237 included, are used by the bricklayer and his helper. There are other tools also made use of that are not included in this list, such as the iron or steel square, various forms for shaping bricks, trestles, stands and other appliances for special work; but the ones shown cover the main ground. There is: 1, the pick for breaking up hard ground; 2, the grafting tool for digging out earth such as stiff clay; 3, the shovel; 4, the chalk line; 5, boning rod, for taking levels; 6, spirit level; 7, hod made to carry about 12 bricks, or ⅔ of a bushel of mortar; 8, a larry or hoe for mixing mortar; 9, the beedle or mall, is a large wood mallet with a circular pine head, with rounded ends about 18 in. long and 15 in. in diameter, with a handle about 3 ft. long. It is used by the pavior for punning paving stones into their position when bedding, as shown in Fig. 238; 10, the rammers are of two kinds—1st, that used for ramming granite sets in roadways, which consists of a cylindrical piece of wood

*Much of the foregoing matter has been taken from "Bricklaying and Brick-cutting," by H. W. Richards, a most excellent work.

about 3 ft. 6 in. long, with a vertical handle at top and a horizontal handle about half-way up, as shown in Fig. 239; 2d, that used for the bottoms of trenches and for consolidating ground. They are of the shape shown in Fig. 240, the head being of iron and about 10 lbs. in weight; the handle is of ash, about 10 ft. long.

Bricklaying Tools.—1, large trowel used for the spreading of mortar and the bedding of bricks; 2, the 2-ft. rule; 3, the plumb-rule and bob for the carrying

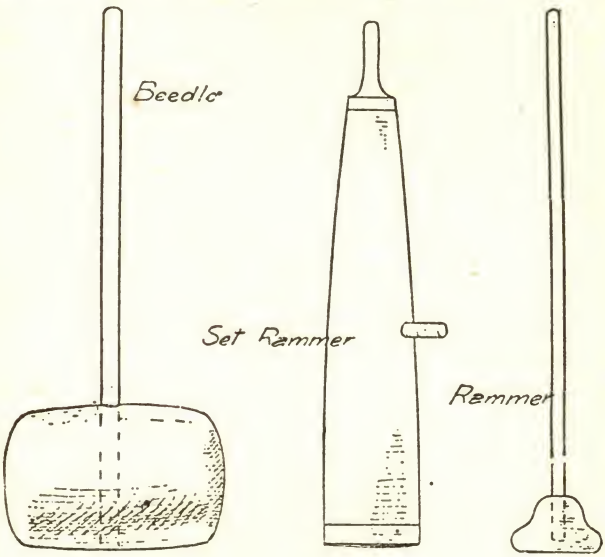


Fig. 238. Fig. 239. Fig. 240.

up of walls perpendicularly; 4, the short straight-edge, about 3 ft. in length, with the brick courses marked on it for the building up of corners; 5, the spirit level for testing the horizontality of work; 6, line and pins for building the portions of walls straight between corners.

Brick-cutting Tools.—Rough cutting: 1, the large trowel; 2, the club hammer and bolster, for cutting with greater exactitude than with the trowel; 3, the cold chisel for the cutting of chases and for general work.

Fair cutting, hard bricks: 1, the tin saw for making an incision ⅛ of an inch deep, preparatory to cutting with bolster; 2, the chopping block, which is an arrangement of two blocks of wood so fixed as to support a brick in an angular position convenient for cutting; 3, the scutch consists of a stock and a blade, the latter generally formed of a flat file about 10 × 1 in., sharpened at both ends and fixed in the stock by means of a wedge. This displaces, and is an improvement on, the old brick axe, as the blade can be removed and sharpened readily; it is used to hack away the rough portions on the side of a brick after the edges have been cut by the tin saw and bolster.

Fair cutting, soft bricks: 1, the saw consists of a frame holding the blade, which consists of twisted soft steel or malleable iron wire (No. 16 B.W.G.), and is used for cutting soft rubbing bricks; 2, the rubbing stone is a circular slab of gritty stone 20 in. in diameter, for rubbing the faces of bricks to a true surface; 3, the mould is a wood box enclosing bricks that are to be cut to a shape, the sides of the box being formed to that shape, and the edge over which the saw blade works is protected by a strip of zinc; 4, the square, bevel, and compasses are used in the setting out of work.

Pointing tools consist of: 1, small trowels for filling up joints of new brickwork; 2, the pointing rule, which is a feather-edged straight-edge with two small pieces ⅜ in. thick nailed at each end to keep the rule away

from the wall and allow the trimmings to fall through; 3, the frenchman, for trimming joints, consists usually of an old table knife, with the end ground and turned up, as shown in plate; 4, the jointer, used for tuck pointing in old work.

BRICKLAYER'S MORTAR

Mortar.—The mortar is composed of one of lime to two or three parts of sand, or from one of Portland cement to one to four of sand. Lime mortar sometimes has cement added to it to increase its strength and hasten its setting.

Lime mortar should not be used when fresh nor in an untempered condition, as in that state its cohesive value is small and it is difficult to work; but after making should be left two days at least, then turned over and beaten up again.

This tempering gives it the property of working evenly and fat. Cement mortar should be used as soon after making as possible, as the setting action commences immediately after mixing and any further working up of the mortar lowers its ultimate strength.

Building During Frosty Weather.—All brickwork should be suspended during frosty weather, as its stability is endangered by the disintegration of the mortar by the frost while it is wet. When the work is urgently required it should be carried up in cement mortar in the intervals between the frost; but all the freshly built portions should be carefully covered and protected on any recurrence of the frost.

Technical Terms.—Course is the name given to the row of bricks between two bed joints; the thickness is taken as one brick plus one mortar joint, in this work;

unless otherwise stated, it will be considered as 3 in., or, as technically described, four courses to the foot.

It usually requires about 1⅛ barrel of lime and 1 yd. of sand to make the mortar for 100 bricks, and one man with 1¼ tender will lay 1,500 to 2,000 bricks per day; that is, four masons and five helpers will lay about 8,000 brick, but this should be reckoned on straight walls.

The same proportions of sand and lime, or cement and lime, may be used also for masonry.

Allow 12 bushels sand to one barrel.

Allow about .0012 bushels fire clay for each 100 brick and 1 barrel of Portland cement to 800 brick.

A load of mortar is equal to one cu. yd. It requires 1 cu. yd. of sand and 9 bushels of lime; it will fill 30 hods.

A bricklayer's hod measures 1 ft. 4 in. × 9 in., equals 1,296 cu. in. It holds 20 bricks and weighs about 113 lbs. when full.

A single load of sand is equal to 1 cu. yd.; a double load, 2 cu. yd. A measure of lime is one load.

One barrel of fire clay will make a thin mortar for 1,000 bricks.

One part cement to two parts sand for cement mortar.

Mortar.—One part of lime to 3 or 3½ parts of sharp river sand; or 1 part of lime to 2 of sand and 1 of blacksmith's ashes.

Brown Mortar.—One-third lime, two-tnirds sand, and a small quantity of hair. This is for plastering.

Coarse Mortar.—One part of lime to four of coarse gravelly sand.

One rod of brickwork requires 1 cu. yd. of lime and 3½ single loads of sand; or, 36 bushels of cement and 36 bushels of sharp sand.

One yard, or 9 superficial feet, 1½ bricks thick, requires 2¼ bushels of cement.

One superficial yard of pointing brickwork in cement requires ⅛ of a bushel.

Some kinds of cement set so fast that it is not safe to mix more than can be used within twenty minutes.

Mortar made of cement, worked after it begins to set, becomes worthless.

The following are the rules generally used by masons in figuring brickwork:

Corners are not measured twice.

Openings over two feet square are deducted.

Arches are counted from the spring.

Pillars are measured on the face only.

To find the number of bricks in a wall.

4½	in. wall per superficial foot....	7 bricks.
9	in. wall per superficial foot....	14 bricks.
13	in. wall per superficial foot....	21 bricks.
17	in. wall per superficial foot....	28 bricks.
22	in. wall per superficial foot....	35 bricks.
26	in. wall per superficial foot....	42 bricks.
30	in. wall per superficial foot....	49 bricks.

And seven bricks additional for every half brick added to the thickness of the wall.

One foot superficial of gauged arches requires 10 bricks.

One thousand bricks closely stacked occupy about 56 cu. ft.

One thousand old bricks, clean and loosely stacked, occupy 72 cu. ft.

Stock or place bricks generally measure 8¾ × 4¼ × 2¾ in., and weigh from 5 to 10 pounds each.

GENERAL SPECIFICATION CLAUSES

MATERIALS

BRICKS

1. All bricks intended for use under this Specification must be the best of their respective kinds, hard, square, sound, well-burnt, and even in size. No brick must absorb more than one-sixth of its dry weight in water during one day's immersion. Samples of each kind, selected at random from the load, must be deposited with and approved by the architect before any of that particular kind are laid.

NOTE.—If the bricks are not specified from particular makers the following may be added to the foregoing clause:

And the architect is to be informed from what manufacturers the bricks are being obtained, if he so desires.

All bricks shall be carefully handed from the carts and stacked, and no broken bricks or bats are to be brought upon the ground.

2. All hard, sound, clean, and approved old bricks, obtained from pulling down the old buildings on site, may be re-used where directed.

3. The stock bricks are to be (obtained from . . . .) *or* (equal to the manufacture of . . . .) similar in all respects to the samples deposited with the architect.

4. The stock bricks for facings are to be carefully selected for their evenness of color and face, and the visible arrises must be undamaged.

5. The pressed (red) facing bricks are to be (obtained from . . . .) *or* (equal to the manufacture of . . . .) similar in all respects to the samples deposited with the architect. In all cases the visible arrises must be undamaged.

6. The hard, wire-cut gault bricks are to be (obtained from . . . .) *or* (to be equal to the manufacture of . . . .) similar in all respects to the samples approved by the architect.

7. The cutters or rubbers are to be obtained from.......... or other approved manufacturer, equal in quality, free from all lumps and flaws, and similar in all respects to those approved by the architect.

8. The salt-glazed facing bricks must be slip-glazed, and are to be obtained from............or other approved manufacturer They must be fairly uniform in tint and equal in all respects to samples approved by the architect.

9. The salt-glazed bricks are to be obtained from............ or other approved manufacturer, fairly uniform in tint, and equal in all respects to samples approved by the architect.

10. Reveals, arches, projecting piers, etc., in salt-glazed work are to have bull-nosed angles. Any squints, etc., to be in salt-glazed quoins to required angle.

11. The enamel-glazed bricks are to be obtained from ....or other approved manufacturer. Samples of the required color or colors must be deposited with and approved by the architect before any of this work is executed. Provide enamel-glazed bull-nosed angle bricks for reveals and arches to windows and door, projecting doors, etc. Provide all enamel-glazed quoins to required angles for squints, etc.

12. The firebricks are to be obtained from............or other approved maker (raw and unburnt) *or* (thoroughly burnt and vitrified), and equal in all respects to the samples approved by the architect.

13. The smoke flue pipes (with air flues combined) are to be of the best fireclay, and of approved stock pattern, to be obtained from............, and equal to the samples approved by the architect.

14. The moulded strings, stops, cornices, angles, sills, jambs, plinths, panels, and keys, etc., shown on details, are to be obtained from the same manufacturer supplying the facing bricks, and of similar make, equal in all respects to the samples approved by the architect.

15. The coping bricks are to be (as per detail drawing) *or* (of approved stock pattern), from............or other approved maker..........inch by........inch, straight, and even colored, and all arrises and angles must be perfect.

16. The bonding bricks for hollow walls are to be obtained from............, of improved bent pattern, equal to samples approved by the architect, and of the following size: Lower

flange,......inch; middle flange,......inch; upper flange,..... inch.

17. The..........bricks for (the $4\frac{1}{2}$-inch groined arch work) are to be made by............or other approved maker, each brick cut to the proper size and radius as shown on the detailed drawing, and marked before it leaves the works with a number corresponding to that on the drawing showing its proper position in the arch.

SAND, ETC.

18. To be clean, sharp, pit or fresh-water sand, coarse grained, and of approved quality. To be entirely free from loam, clay, dust, or organic matter. If directed it must be washed, when used with cement.

19. If the lime mortar is mixed in a mortar mill, the architect, at his discretion, may allow the contractor to substitute a certain proportion of clean, hard brick, hard burnt ballast, or other approved material in lieu of sand. Such permission shall be given in writing, and shall clearly state the exact proportion of the substitute material which the contractor will be allowed to use.

WATER

20. The whole of the water required for the works must be perfectly fresh and clean, and free from any chemical or organic taint.

LIME MORTAR

21. The limes for mortar shall be the best of their respective kinds, obtained from (manufacturers approved by the architect) (the firms hereinafter specified), and shall be fresh burnt(and ground) when brought on the works.

(*Add the following if firms are not specified:*)

The contractor shall supply the architect, at the latter's request, with the names of the firms from whom the lime has been obtained.

(*Add the following if firms are specified:*)

The contractor shall satisfy the architect, if required by him to do so, that the lime is being obtained from the specified firms.

(*Add the following where ground lime is specified:*)

The contractor must satisfy the architect, by analysis or otherwise, that the lime is not adulterated or air-slaked.

22. The lime shall be thoroughly slaked at the scene of operations by the addition of sufficient water. During the process it shall be effectually covered over with sand to keep in the heat and moisture. All lime must be used within ten days of slaking.

23. The contractor shall, at his own expense, provide a proper mortar mill, worked by steam or other approved power for the due incorporation of the materials, and all expenses in connection therewith shall be defrayed by the contractor.

24. If a mortar mill is not provided for the making of the mortar, the contractor will be required to thoroughly screen the materials before mixing to get rid of any dangerous and refractory lumps.

25. A proper stage is to be provided to receive the lime mortar when made. The mortar in no case to be deposited on the ground.

26. The materials for all lime mortars are to be measured in the proper stated proportions, in quantities sufficient only for each day's requirements.

27. Fat lime mortar must not under any circumstances be used for the purposes of the specification.

28. The stone lime mortar for brickwork above ground level shall be composed of one part of gray lime (obtained from......) and two (three) parts of sand, mixed with a sufficiency of water and thoroughly incorporated together (in a mortar mill). (The lime and sand shall be mixed together in their dry state before being put into the mortar mill.)

29. The lias lime mortar shall be composed of one part of blue lias lime (obtained from..............), and one part of sand, mixed with a sufficiency of water and thoroughly incorporated together (in a mortar mill). (The lias lime mortar for brickwork above ground level shall be made in the same manner, but in the proportions of one part of lime to two parts of the sand.) (The lime and sand in their dry state shall be mixed together on a proper stage before being put into the mortar mill.)

30. The blue mortar shall be composed of three parts of fine foundry ashes, two parts of ground stone lime, and two parts of sand

CEMENT MORTAR

31. A proper stage is to be provided for mixing Portland and Roman cement mortar upon, and the water must be added from a can with a fine rose.

32. No cement mortar that has become partially set shall be revived or re-used.

33. The Portland cement shall be obtained from............ (an approved maker), and shall be of the best quality composed entirely of thoroughly well burnt clinker ground fine enough to pass a sieve of 2,500 meshes to the square inch, without leaving more than 10 per cent behind. The cement shall not contain more than 1 per cent of magnesia and 63 per cent of lime. It shall weigh not less than 112 lb. per striked imperial bushel when lightly filled into the measure from an inclined trough placed 12 in. above the top of the measure.

Test briquettes made of the cement, mixed with 18 per cent by weight of water, shall be capable of maintaining—after seven days' immersion in water—a tensile strain of 350 lb. per square inch, the immersion to commence within twenty-four hours of the briquettes being made. The temperature of the atmosphere and water in which the test briquettes are made shall not be less than 40° Fahr. The tensile strain shall be applied at the rate of about 400 lb. per minute.

Samples of the cement when made into a paste with water and filled into a glass bottle or test-tube must not in setting become loose by shrinking from the sides, or crack the vessel.

34. The cement shall be emptied and spread upon the dry wooden floor of a covered shed to a depth not exceeding 2 ft. for a period of not less than 14 days (or such other period as may be considered necessary) and shall be turned over from time to time as may be directed by the architect.

35. The cement shall be delivered on the works in such quantities as to allow sufficient time for testing before being required for use, and the contractor shall be entirely responsible for any delay or expense caused by the rejection of cement which does not satisfy the special requrements.

36. The Portland cement mortar shall be composed of one part of Portland cement to two parts (one part) of sand, mixed together, turned over, and thoroughly incorporated with a sufficiency of water. It is to be made in small quantities from time to time as required, and must be used within one hour of mixing.

37. The Roman cement is to be of the very best quality, and obtained from an approved manufacturer. The raw stone shall be fine grained, and after being thoroughly burnt, shall be ground to a fine powder The finished cement must not weigh more than

78 lb. per striked bushel, or more than 70 lb. per trade bushel, and must be stored in air-tight drums or casks, and kept in a dry place in free air currents.

38. The Roman cement mortar shall be composed of one part of Roman cement and one part of sand, mixed together with a sufficiency of water and thoroughly compounded. Owing to the quick-setting property of the cement, the mortar must be mixed by an experienced workman close to the position at which it is required and used immediately. When once partially set, it must not be revived.

39. The selenitic cement is to be obtained from the patentees, and mixed and used in accordance with the printed instructions issued by them.

40 The fireclay is to be of the best quality, and from the same manufacturer supplying the firebricks.

DAMP COURSES

41. The damp course is to be formed with stoneware (fireclay) perforated vitrified blocks ....in. by ....in., and of the several widths required for the respective walls. The blocks are to have ribbed surfaces and tongue and grooved joints.

42. The bituminous sheet damp course is to be obtained from .... and laid (in accordance with their instructions) by them (the contractor given due and reasonable notice, as arranged, when the walls are ready, so that there may be no delay).

WORKMANSHIP CLAUSES FOR GENERAL WORK

PRELIMINARY

43. All brickwork is to be set out and built of the respective dimensions, thicknesses, and heights shown on the drawings.

44. All bricks are to be well wetted before being laid. The tops of the walls where left off are to be well wetted before recommencing them, as often as the architect may deem necessary.

45. All joints are to be thoroughly flushed up as the work proceeds. The vertical joints in the heading courses of English bond are to receive special attention.

46. Carry up walls in a uniform manner, no one portion being raised more than 3 ft above another at one time. All perpends,

quoins, etc., to be kept strictly true and square, and the whole properly bonded together and levelled round at each floor.

47. No brickwork is to be carried on during frosty weather, unless with the written permission of the architect who will give special directions as to the manner in which the work is to be performed. All brickwork laid during the day shall (in seasons liable to frost) be properly covered up at night with felt, sacking, boards, or other approved non-conducting material. Should any brickwork, laid on the day previous to a frost, become affected or damaged through not being covered or properly protected as previously specified, or by reason of the exceptional severity of the weather, the architect, at his discretion, may require the whole or any part of such brickwork to be removed and reinstated by the contractor at his own expense.

BOND

48. Brickwork generally except facings (all brickwork) to be laid in English bond consisting of alternate courses of headers and stretchers. Snap headers will not be permitted, and bats only as closers.

49. All facings are to be executed in Flemish bond, consisting in each course of headers and stretchers alternately, to break joint accurately.

50. Cut indents in alternate courses of existing brickwork, and tooth and bond new brickwork to same in cement mortar.

51. Lay in walls, at intervals of four courses, a layer of 1½ in. stabbed hoop-iron to each 4½ in. of thickness of wall, lapped or hooked at all angles.

JOINTS AND POINTING

52 The height of four courses of bricks laid in mortar is not to exceed by more than one inch the height of the same bricks laid dry.

53. The exterior facings are to be pointed with a neat weather joint in cement (blue mortar) cut in top and bottom, a sample of which is to be approved.

54. The interior facings to cellars are to be pointed with a flush joint neatly struck with the point of the trowel.

55. The joints to gauged work are to be pointed with....... (time putty) (cement mortar).

56. The enamel and salt-glazed facings to be flush pointed in

Parian cement, tinted to color of the glaze, the white enamel-glazed facings to be flush pointed in Keen's cement.

57. All internal walls, excepting those otherwise described, to be left rough for plaster.

58. Rake out joints for and point to all flashings in cement and also all frames.

FOOTINGS AND PIERS

59. Footings to be formed to spread on each side of the walls, half the respective thickness of same at base, diminishing in regular $2\frac{1}{4}$ in. offsets to proper thickness of walls. The courses of footings are to be laid of headers where practicable.

60. All underpinning to be executed with approved hard bricks, laid in cement mortar, well grouted at every course, and carefully wedged up with slate, provided by the contractor.

61. Lay over the full thickness of all walls and piers at the levels shown on drawings the........ horizontal damp course.

62. The outside faces of vault walls, dry areas to have approved asphalt damp course, $\frac{1}{2}$ in. thick, laid thereon from the level of horizontal damp course to top of walls, and continued over top of vaults, and turned up around coal or ventilating plates or pavement lights, as required, to make vaults thoroughly water-tight.

63. All isolated piers carrying weights, and elsewhere if described, to be built in pressed bricks laid in cement and grouted at every fourth course.

64. Build honeycomb (solid) fender walls on proper footings to ground-floors where shown.

65. (*a*) Build up dry area wall as shown on drawings in cement mortar, arched over into main wall three inches below ground level.

(*b*) Build up dry area wall as shown on drawings in cement mortar. Bed and point stone cover (provided by "Mason"), as shown, in cement mortar.

WALLS GENERALLY

66. Build in, or cut, bed, and pin in, all sills, thresholds, steps, landings, corbels, ends of joists, etc., in cement, and point as required. Build in frames, bedded solid in reveals, where specified to be built in.

67. Brickwork to be well pinned and backed up to all stonework and terra-cotta, and cut and fitted to ends of all steel joists, girders, lintels, etc.

68. Build in brickwork where required, fixing blocks (provided by "concretor") for fixing carpenters' or other work.

69. Build half-brick walls, small piers between windows and elsewhere as directed, in cement mortar.

70. Build chases and reveals in walls to receive frames, pipes, light wiring, etc., as shown on drawings, or required.

71. Bed all plates, lintels, templates, cover stones, etc., in cement as required.

72. Neatly cut and fit all facings to stone or terra-cotta dressings, arches, etc., and execute all rough and fair cutting as required.

73. Leave horizontal chases in walls to receive concrete floors or build sailing courses as shown to support same.

74. Turn rough segmental relieving arches in cement over all lintels where practicable.

75. Oversail where possible to support concrete floors and projections and to receive plates.

76. Level up on top of all riveted girders with plain tiles and cement.

77. Build in................air bricks (provided by "terra-cotta and Faience worker") ("founder"), where shown on drawings, and form cranked air-ducts to them in the wall, rendered in cement and sand.

78. The panels intended for carving are to be executed in rubber brick, as shown on drawings, set in shellac.

79. All niches, panels, and other enrichments to be executed in ....as shown on drawings.

FIREPLACES, CHIMNEYS, ETC.

80. Build in over each fireplace opening a wrought iron bar, provided by "smith," turn rough brick segmental arch over same in two rings, and properly contract the opening, and form throats to flues as detailed.

81. Build all smoke and ventilation flues of full bore shown, graduate all bends and parget flues as the work proceeds, and carefully core same, leaving openings in face of chimney-breasts where required for coring, and afterwards pin up same and make good.

82. Line all flues shown circular on plan with........in. unglazed terra-cotta flue pipes, and provide all requisite bends, purpose made or otherwise.

83. Properly bond the withes and other brickwork of all flues.

84. Build all chimney stacks above roof line in cement mortar with selected pots set in same, and well flaunched up and weathered in cement, to detailed drawing, joints left open for pointing as other brickwork.

85. Rough render all chimney-backs, and also brickwork to flues where near woodwork, in cement.

86. Carefully set all stoves, provided by "founder," with brick in mortar backing, fix iron and wood mantels securely with iron cramps pinned in cement; set kitchener in accordance with instructions with firebrick flues, and provide all firelumps, fireclay, etc., required.

87. Carefully set, where shown on drawings, all flue plates and soot doors and frames, provided by "founder."

88. Set in brickwork, as described, with firebrick linings in fireclay to flues, furnace pan, including all ironwork, dampers, soot doors, etc., provided by "founder"; the top and front to be rendered with Portland cement and sand, in equal proportions, ¾ in. thick.

89. Turn half-brick trimmer arches in cement 18 in. wide and 12 in. longer at each end than the width of the openings to all fireplaces where there is no support underneath.

90. Bed and point hearthstones in cement mortar.

FACINGS

91. Face the whole of the........excepting where otherwise specified, with best selected stock bricks, uniform in color.

92. All arches occurring in stock brick facings to be segmental arches in second quality malms, axed and set in cement.

93. Face the elevations tinted..........on drawings with ....'s first quality........facing bricks, carefully executed in accordance with details of elevations. Build all moulded strings, cornices, angles, etc., in similar red bricks, with moulded stops as shown on details.

94. Turn over all basement openings in........elevations, plain segmental arches in........rings in cement. Turn over all other openings where shown in brick on........elevations, gauged arches in red rubbers, accurately and closely jointed. That elliptic arches over........floor openings on........elevations to have voussoirs of similar gauged rubbers, alternating with terra-cotta voussoirs, provided by "terra-cotta and Faience worker," and moulded to details.

95. Face the following portions of back elevations: the light area to............and also the walls of lavatories in vaults, with..............quality..............bricks in fine mortar.

96. Reveals and arches to windows and doorways occurring in glazed work are to have bull-nosed angles, also all projecting piers in lavatories to have ditto. Any squints, etc., to be in white glazed quoins to required angle.

97. Turn segmental arches in glazed half brick rings in cement over openings as shown on elevations.

SUNDRIES

98. Build 4½ in. (glazed brick) piers (in scullery), where shown on drawings, to support stoneware (stone) sink, and properly bed and point same in cement mortar.

99. Cope parapets where shown to have brick coping, with two courses of plain tiles bedded in cement to project 1½ in. from faces of wall, or.............. patent drip tiles, and brick on edge coping the thickness of wall bedded and pointed in cement mortar and ramped as required.

100. Cope parapets and other walls where shown with purpose made coping bricks the thickness of the wall, pattern No......... ....'s list, bedded and pointed in cement mortar..

101. Bed and point stone copings, provided by "mason," in cement mortar with the joints joggled.

102. Cut and pin in ventilating flues where shown approved ventilators, provided by "ventilating engineer."

103. The contractor shall, before pointing, clean down all brick facings, and make good all putlog and other holes throughout the work as it proceeds, and point the same.

104. Cut away, etc., as required for other trades, and make good after same.

For Limewhiting, see "Painter's Specifications."

HOLLOW WALLS

105. Build up the hollow walls as shown on drawings in two thicknesses, the outer thickness to be 4½ in., the inner........in., with a 2½-in. cavity between, the thickness of the entire wall being ....in. Bond the two thicknesses together with........ wall ties placed at a distance apart of 3 ft. horizontally and 12 in. vertically. The cavity is to be kept clear of all rubbish or

mortar droppings by movable boards or other means. Leave openings at the base and clean out the cavity at completion, the openings afterwards to be bricked up uniform with surrounding work. The wall ties to be carefully laid and in no case to fall towards the inner thickness of the wall. Build into inner face of exterior thickness over all frames a piece of sheet lead, provided by "plumber," projecting 2 in. beyond each side of lintel and turned up 1½ in.

DAMP-PROOF WALLING

106. Build up the walls in two thicknesses, the outer thickness being 4½ in., the inner thickness..........in., with a ½-in. cavity between, the total thickness of the wall being..........in. The bricklayer is to leave the cavity face joints free of mortar for a depth of ½ in., the cavity being kept clear of mortar droppings with a movable plain board. At a height of every four courses fill up the cavity with..............building composition, prepared and used according to instructions.

RETAINING WALLS

107. The retaining wall to be carried up according to the detail drawing, to be built of..........bricks laid in cement mortar grouted at every fourth course, to have the exterior face battered, the inner face finished with (diminishing offsets) all as shown.

108. Build in where shown 3 in. land drain pipes to run through the entire thickness of the wall, cut bricks to fit, and make good around same in cement mortar.

FACTORY CHIMNEY SHAFT

For specification of Iron Cap, see "Founder." For Lightning Conductor, see "Electrician." For Painting Iron Cap, see "Painter and Decorator's Specifications."

109. The whole of the brickwork throughout, including footings, walls, arches, string courses, cornices, etc., is to be built and carried up in accordance with the drawings, and is to be of the various thicknesses, heights, etc., or other dimensions as shown thereon, finishing at the top length of........ft., which is to be........ft........in. in thickness and is to be set in cement mortar.

110. All brickwork, except where otherwise specified, is to be built in lime mortar and in old English bond.

All the walls are to be carried up uniformly all round, and no part is to be left more than 3 ft. lower than any other. Each course is to be carried up to a uniform level throughout, and the whole of the work is to be built true, and the perpends strictly kept.

111. Two arched openings are to be formed (........ft. by ....ft.) in the base of the shaft, as shown, for the connection of the main flues thereto. The semicircular arches over openings to be turned in three 4½ rings of brickwork carefully bonded in mortar and lined with firebrick.

112. Form sunk panels in each side of the square pedestal base of the dimensions, and after the manner shown upon the drawings.

113. The brickwork is to be built with neat close joints not exceeding ¼ in. in thickness, and no four courses of bricks to rise more than 1 in. in addition to the height of the bricks laid dry.

The cross joints are to be put in solid throughout the whole width of the bricks and the wall joints flushed up solid, and grouted with every course.

The bricks for facing must be properly bonded in at each course with the brickwork as the work proceeds.

114. The contractor shall do all cutting required for forming openings, splays, miters, chases, circular work, indents, recesses and skewbacks, and shall make good all putlog and other holes throughout the work as it proceeds, and point the same.

115. The whole of the exterior brick facing is to be pointed with a neat flat joint, and is to be jointed.

The interior faces of walls are to be jointed with a neat flat and flush joint.

116. The........ft. by........ft. main flue entrance in the base of the shaft which is not required for immediate use is to be built up as shown on plan, with 14-in. brickwork, consisting externally of 9-in. ordinary bricks and 4½ in. internal facing of firebrick properly bonded thereto.

117. Build in a 3-in. cast-iron pipe (water main strength), with a screw hexagonal cap and spanner through the brickwork in the position shown upon the plan, for the purpose of inserting testing apparatus, etc.

118 The........brick cornices to be constructed in the topmost........ft length of the shaft, are to be of depths and projections shown upon the plans. They are to be thoroughly

well bonded together and set in cement, and if considered necessary by the architect are to be further secured with metal cramps run in with lead.

119. In the topmost length of the shaft, and between the two projecting blue brick cornices above mentioned, five projecting ribs are to be formed of facing bricks on each side of the octagon, as shown on the drawings. These ribs are to be spaced 4½ in. apart in the clear, are to be 4½ in. in width on the face, to project 3 in. from the face of the shaft, and are to extend......ft. in length. They are to be properly corbelled out at the bottom, and finished at the top with splayed blue bricks. All to be set in Portland cement mortar.

120. The shaft is to be internally lined with firebrick from the level of the floor of the main flue at its entrance at the base of the shaft to a height of........ft. above floor of main flue. The firebrick lining is to be built circular, is to be 4½ in. in thickness and is to have an internal diameter of........ft. throughout its height. An air space of 2½ in. in width is to be maintained at the back of the firebrick lining, between it and the ordinary brickwork. At the upper extremity of the firebrick lining this air space is to be completely oversailed with firebricks bonded into the brickwork, and projecting as shown on the plan. The contractor must be very careful to keep the air space perfectly clear of mortar or rubbish of any kind. To permit of an air current between the lining and the brickwork, a sliding grid ventilator is to be built in each face of the base of the shaft, near the ground level and a corresponding grid without slides is to be built in each case of the shaft just under the out-sailing course at the top of the lining. All firebrick linings are to be built of the best ....purpose-made radius firebricks, well wetted before use, solidly and truly set with the closest possible joints, in pure fireclay cement. The firebrick lining is to be bonded or stayed at intervals as may be necessary for securing same by firebrick bonders into the ordinary brickwork.

BRICKWORK DURING FROST

122. The bricks to be used for brickwork during frost shall be kept under cover free from moisture or frost. They are to be taken out only in small quantities as required for use, and are not to be wetted previous to being laid.

123. The water, sand and lime for the mortar must similarly

be kept under cover, free from frost. The lime is to be ground unslaked lime, mixed with the sand in the proportion of one part of lime to two parts of sand. Where the temperature is under 26° Fahr. the proportions shall be one part of lime to one part of sand. The mortar shall be mixed in ashes having a temperature of not less than 34° Fahr. in small quantities as required and used immediately.

124. The brickwork is to be executed as rapidly as possible consistent with good workmanship, and the courses shall be immediately covered with sacking as the work proceeds.

125. If the temperature shows the presence of more than 12° of frost, i. e., a temperature less than 20° Fahr., the work shall be immediately stopped.

Note.—The following are for brickwork for other trades.

FOR "DRAINLAYER" (HOUSE DRAINAGE)

126. Construct the manholes to the sizes and depths shown on the drawings, all depths being calculated from the inverts of the main channels in the manholes. The manholes are not to be built until the pipes entering them, have been properly laid and jointed.

127. The walls to be built of the full dimensions shown on the drawings in selected hard stocks laid in cement mortar in English bond. (The interior face joints for a distance of......ft. above the benches are to be left rough as a key for the rendering.) All (other) joints to be thoroughly flushed up with cement mortar, and are to be neatly struck with the point of the trowel. Point in cement the (exposed) brickwork to interior faces of manholes.

Note.—Some architects prefer to have manholes in stock bricks rendered on the interior faces in cement and sand. If rendering is not desired leave out the words in brackets.

128. The walls to be built of the full thicknesses shown on the drawing, of good hard stocks, with interior facings of (enamel glazed) (salt glazed) bricks in cement mortar in English bond, the joints to be well flushed up, grouted at every fourth course, the brickwork to interior faces being pointed in pure cement and neatly struck with the point of the trowel.

129. To be built as other manholes, but in addition to have a small brick chamber constructed at the side. 14 in by 14 in. by 27 in. in the clear, as shown on drawings An aperture to be formed in the division walls, and to have a..........mica valve

built in as shown on drawings as near the top of the manhole as practicable.

130. A chamber is to be formed at one end of........manholes by turning an arch in two 4½- in. rings from side to side as shown on drawings. The height of such chamber from the invert of the main channel to be 6 ft.

131. A chamber is to be formed at one end of the........manhole by partially roofing over with a good stone cover or landing as shown on drawings. The height of such chamber from the invert of the main channel to the underside of the stone to be not less than 6 ft. or more than 6 ft. 2 in. as the courses of brickwork allow.

132. Build up the walls to the heights, lengths, and thicknesses shown on detail drawing (1 stock 2. blue) bricks laid in cement mortar (1. the interior face joints left rough for rendering) (2. grouted in at every course and the joints being neatly struck with the point of the trowel). Form an aperature in division wall 9 in. by 12 in. as shown. Build in stone cover to aperture, stone templates under R. S. joists, hooks for grating chains, etc., as shown on detail. Secure grating channel to walls of filter chamber with holdfasts driven 6 in. into the brickwork. (1. The whole of the interior faces of tank and filter to be rendered and smoothly troweled in cement and sand ¾-in. thick.)

133. Build in the ends of all pipes at the heights and levels shown on the drawings, or as directed by the architect during the construction of the manholes, rain water tank, and filter etc. Build in step-irons at a height of every four courses of brickwork where shown on plan.

134. All drainpipes passing through manhole, R. W. tanks, filter, or other walls or foundations are to have arched openings formed for them so that they can be withdrawn without cutting and to prevent fractures from settlements.

135. The entrances to manholes, R. W. tanks, filter, etc., are to be corbeled over to the necessary openings for covers, as shown on drawings.

136. The walls to be 9 in. in thickness, built of stock bricks, laid in cement mortar or English bond. The interior face joints of brickwork to be left rough for rendering. The walls to be carried up perpendicularly for flat stone cover.

137. Bed and point all stone covers and landings to manholes in cement mortar bed and point stone covers to cleaning and

inspection eyes, inspection chambers and all movable covers in lias lime mortar.

138. Bed and point all iron cover frames to manholes, R. W. tanks, inspection chambers, lamp holes, etc., where shown on drawings, in cement mortar.

DRAINAGE

139. At the points shown build inspection chambers (or catch-pits),........ft. by........ft. internal diameter, in solid 9-in. stock brick, in cement mortar according to detail, the inlet and outlet pipes being built in as directed.

140. Build up face wall at outfall in good hard stocks, 9 in. in thickness, laid in cement mortar. Build in over the drain mouth close iron grating provided by "smith." The last pipe to be built in to slope slightly downwards and a little projecting in order that the effluent may discharge clear of the face of the wall, all according to detail.

FOR "MECHANICAL ENGINEER"

141. Build the engine bed in stock brickwork, and bed on stone cover supplied by "mason."

142. Build for and set the boilers................according to detail drawing in stock and firebrick.

143. The boiler to be set on fireclay seating blocks, 12 in. long, separated from boiler by wrought iron strips.

144. Line the flues with 4½-in. firebrick and finish against side of boiler with 9 in. by 9 in. quadrant fireblocks.

145. The seating at front end of boiler to be faced out with white enamel glazed brick in fine mortar, and neatly cut to same

146. Line the blow-off pit with white glazed brick as above, with firebrick bottom. Build in iron drain pipe and bed stone cover supplied by "mason."

147. Form main flue under boilers........ft. wide, carry through wall........ft. by........ft. The arched flue to chimney to be........ft. wide and........to crown in 9. in. stock brickwork with 4½-in. firebrick lining.

148. Build manhole to ditto........ft. by........ft. in 9-in. brickwork. Wall up the opening to flue with straight jointed bricks, so as to be removed when required and form sump in ditto.

149. Cover in boiler side and flues with stone flags supplied by "mason."

PRACTICAL BRICKCUTTING.

ARCHED WORK.

Arches Circular in Plan.

In the case of an arch formed in a circular wall, *o, p,* Fig. 1, it will be necessary that the bricks should be cut and stacked in the cutting shed, on a perfectly level and firm bench, and that the turning center should be made to suit the opening and also the curve of the wall close-boarded, and perfectly even on the surface. Strike the curve of the wall, the width of the opening, and also the depth of the arch on each side of the opening; that is, if it is a 3-feet opening, and the arch 9 inches, let the striking on the drawing-board be 4 feet 6 inches or 5 feet wide. Get the carpenter to make three moulds to that curve; fix one of these on the bench at *a*; then erect two upright standards, one at each end of the mould, and firmly fix the other two moulds to these standards, as shown at *b c* and *d e;* then take a piece of board 2 inches wide by half an inch thick, the length from *a* to *e,* tapering from the top downwards, and fix a piece of sheet iron or tin on the face of the bottom or thin end, so as to mark the brick with. This, if held close to the two rails, will accurately scribe the top of each successive course of the arch, taking care to keep it perfectly upright during the operation. The bottom or under side of the brick can be marked from the course underneath.

With this scriber mark the face line over the centre, and take a parallel for the back or depth of the soffit.

Strike the arch to obtain the face moulds in the same way as that adopted for an arch that is straight on the face, and divide the top out into a proper number of divi-

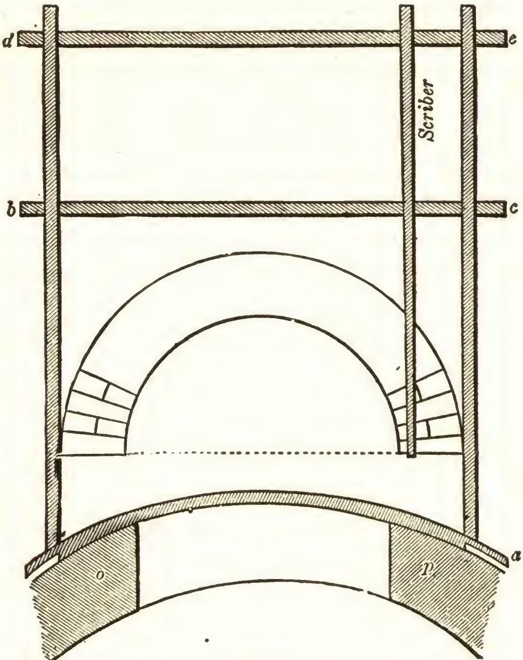


Fig. 1.

sions or courses that will suit the bricks for the thickness it is intended to use, and draw the lines from these divisions to the striking-point. This will give the thickness of the course at the soffit. Then take the compasses and set them to the thickness thus obtained, and transfer it to the centre for turning the arch.

Mark out the courses on the front and an equal number at the back of the soffit; but these will be somewhat less in thickness, owing to the shorter radius. This will give the soffit moulds. The bevels are taken in the ordinary way.

Of course, in stacking this work on the bench, something must be allowed for joints, although, if properly cut, this will be but very little. It would be advisable

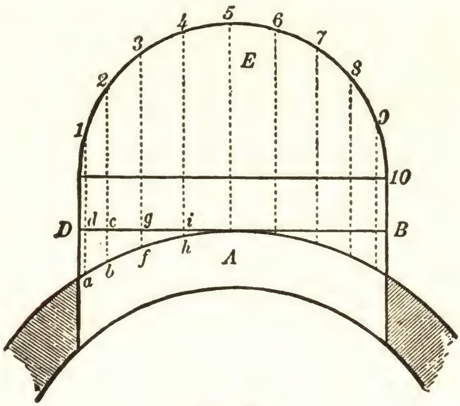


Fig. 2.

to use some thin material, such as stout paper, between each course, that will give the required thickness.

When setting the above the same rule applies as in the case of stacking it, and the same moulds can be used, only the scriber will not be needed, and the middle rail of curve mould should be worked up and down, and the face of the arch set to it by the aid of two profiles erected upright, one on each side of the arch.

The above method is given, as it is a perfectly safe one, and there is no doubt of its being a great deal better

than many of the developments given, for often they savour more of theory than practice.

Nevertheless, as some prefer this way, Fig. 2 shows the manner of stretching out the soffit of an arch in a circular wall. A is an opening, and B, Fig. 3, is the soffit stretched out, which will fit the curve of the wall when bent to the arch, and the jambs stand *square* to the chord line of the opening.

Then, to trace the soffit, divide the arch line E into any number of parts, as in this case ten, but the more there are so much more accurate it will be, and dress lines from these divisions to the chord line D B that touches the curve of the wall.

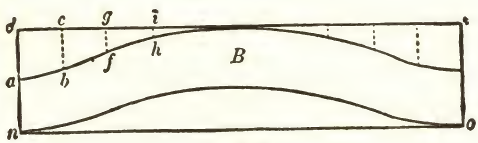


Fig. 3.

Then the length of the line *d, e,* Fig. 3, can be taken by marking off the ten divisions equal to those taken over the arch-line, Fig. 2, which will give the length of the soffit.

Mark the dotted lines between the chord line and the wall, as *a, d, b, c, f, g, h, i,* &c., in Fig. 2, and set them on the divisions of the line *d, e,* Fig. 3, as *a, d, b, c, f, g, h, i,* &c., and that will be the edge of the soffit. When the line is drawn, set on as a parallel *n, o,* and then draw the parallel curve, and this will then be the outlines of the soffit, which can be divided out into courses in the same way as the centre was in Fig. 1.

But the former method will be found the safest and

most correct, for even if this latter way is adopted, the face must even then be scribed to get it correctly.

A Semi-Ellipse, as Drawn by the Trammel.

First draw the horizontal and perpendicular lines at right angles, and take four pieces of ⅜ or ½-inch board, about 1 inch wide and two-thirds of the width of the opening in length, and fasten them on each side of the lines, as shown in Fig. 4, leaving an open groove about

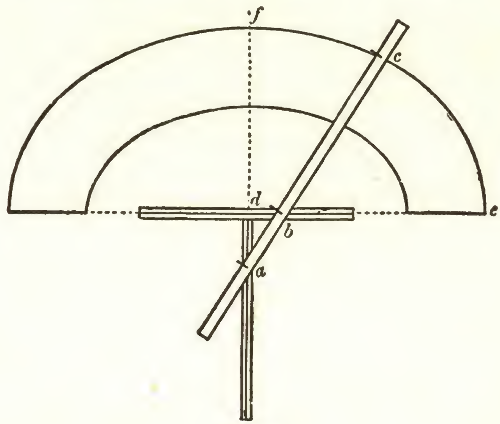


Fig. 4.

a quarter of an inch wide, or large enough to allow a rose-headed screw to work with the head downwards, as the trammel is moved up or down the groove.

This groove must be continuous from the perpendicular, both to the right and left of the horizontal line, and fixed to the drawing-board. Then take a narrow rod, perfectly straight and parallel, about as long as the opening is wide, and at the point *c* make a hole large enough to receive the end of a pencil, and from the centre of this

hole mark the distance from *d* to *e,* half the longest diameter, and fix a screw into the rod; then from the pencil-hole, with the distance *d f,* which is half the shortest diameter, fix another screw as before, and describe the outer ellipse.

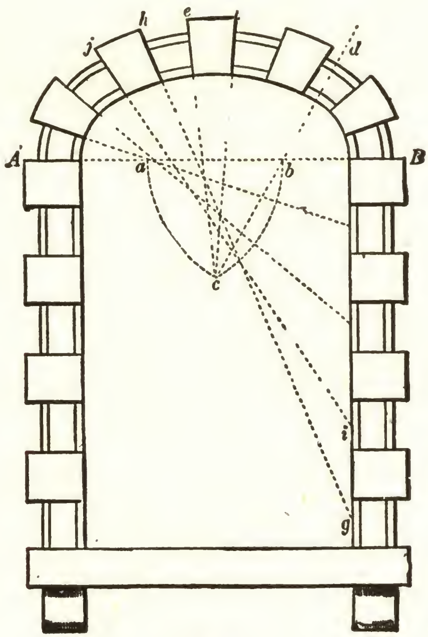


Fig. 5.

Take the depth of the arch from the centre of the pencil-hole number one, and make another hole with which to describe the inner line. This should describe an even and continuous line.

Divide the outer ellipses into as many courses as the

bricks will allow, and draw the bed or "summering" lines for each course, with the side of the trammel as a guide.

After the mould or template for cutting the arch is

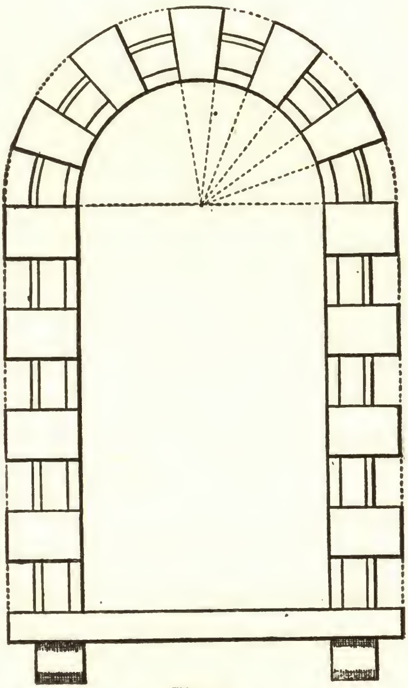


Fig. 6.

made to the lines given, take the bevels for the soffit and mark them on the bottom of the mould, and the bevels for the extrados on the top, as it will be found that the soffit-bevel will not answer for the top when reversed, as it is found to do in cutting many other kinds of arches.

Rusticating Windows.

To proportion the semi-elliptic arch to a window, divide the line A B, Fig. 5, into three equal parts, and taking the length of one of these divisions as a radius with *a* as centre, describe an arc cutting the perpendicular line in *c*; draw the dotted line *c d*, which will give the striking-point for the "haunch" and crown of the arch, both of intrados and extrados; divide the outer arcs and jambs into equal parts, in this case twenty-seven; then for the rustics draw the lines *c e* and *c f* for the key and *g h, i j*, &c., for the remainder, as shown by the dotted lines; then repeat the operation on the other side.

But in this case, where the rustics are required to be equalized out, the filling in of the courses of the arch will be ruled by the rustics, and each one filled out by itself, either by dividing them out top and bottom or by tracing them out with the template, as in the camber arch, for if the radiating lines of the bed joints of the ellipse were taken in the ordinary way the rustics would be very unsightly, and altogether out of proportion.

A Rustic Window with a Semi-Arch.

The semicircular head, Fig. 6, will be more simple, as the lines can, in this case, be drawn to a common center.

The Segment.

Fig. 7 shows a window with a segmental arch. Take the half of the opening, and from the center, *a*, on the line *a b*, describe the arc *d*. This will be the striking-point, and also the common centre to which must be drawn the radiating lines for the rustics and courses of the arch.

This rule will equally apply to an arch with a greater or less rise; the only difference will be the method of obtaining the centre for striking the segment on the perpendicular line, which will be higher or lower as the rise is required.

THE WHEEL ARCH OR BULL'S-EYE.

Fig. 8 shows the proportionate divisions for rusticating the wheel arch, each quarter being divided into nine equal

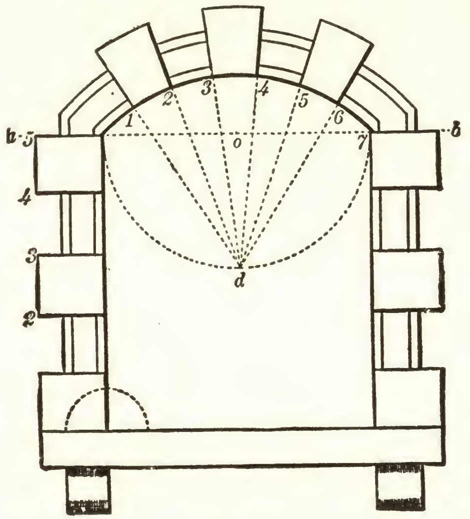


Fig. 7.

parts, of which four form the centres or keys, both of horizontal and perpendicular lines.

The radius of the inner circle is divided into three parts. Taking one of these parts as radius will give the depth of the arch, as shown at the top of the figure.

THE ELLIPSE OR OVAL.

To describe the above, as shown in Fig. 9, take the transverse and conjugate diameters, and set them off on the horizontal and perpendicular lines; let 3 *b* equal *c e;* divide *e* 3 into three parts, and with 3 as centre and 3 2 as radius strike a circle cutting the horizontal line in *h*; with *b* as centre and *h b* as radius describe the arcs *f g;* draw the dotted line from *f* through *h* to *k* and *g h m;* repeat

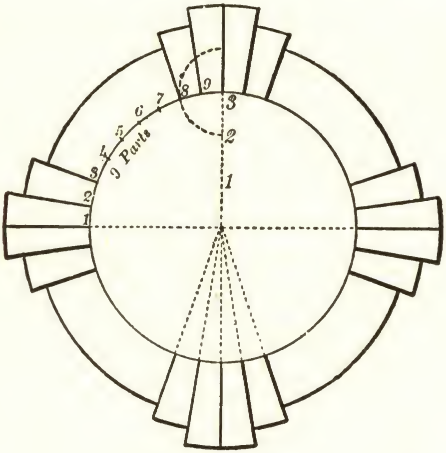


Fig. 8.

the operation on the other side of the upright line for the other centres; then with *h* as centre with *h b* as radius draw the part *g b f,* and with *m* as centre and *m d* as radius describe the upper portion *n d g;* repeat for the other side; after which each quarter of the inner or outer ellipsis is divided into sixteen equal parts, to obtain the rustics and courses of the arch; and lines are drawn from one of these divisions to the other, whereby the rustics

will be uniform and the courses of the arch as nearly as possible equal.

Although in the figure two courses are shown to each rustic, it may be necessary in other cases to put three or more, according to the size of the opening.

Again, there may be a greater number of rustics used, provided the four centre rustics or keys are large ones, and that there is an odd number between them.

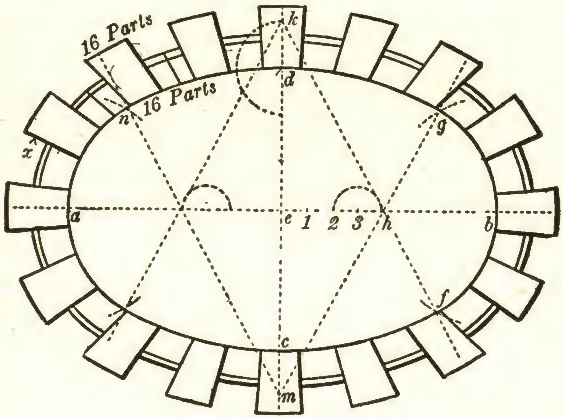


Fig. 9.

The proportionate depth of the small rustic is obtained as shown in the upper part of the figure.

The Niche.

It is the custom in many public buildings to form spaces in the face of the outer walls for the purpose of erecting statues, &c., though it is not unusual to leave them vacant. These spaces are mostly semicircular on plan, are carried up to a given height, and domed over from the back of the semicircle to the face of the wall,

and are called niches. The head or dome of the niche being somewhat difficult to set out, cut, and set, the writer will be pardoned by those who are practically acquainted with the matter if he gives a rather lengthened description for the benefit of those who are not.

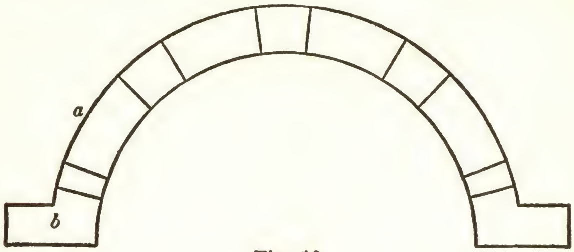


Fig. 10.

The width of the recess having been given, strike the semicircle and set out the bond somewhat shorter than the length and width of the bricks, so that they will (when being worked) hold out long enough for the outer

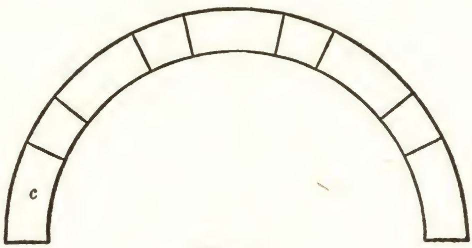


Fig. 11.

circle at *a*, Fig. 10, which shows the first course of the circular body, and let each cross-joint radiate to the centre.

Fig. 11 shows the second course in Flemish bond. As the bricks in each course, whether for the body or head

of the niche, must be cut circular on the face, it is necessary to get a box made with the sides the same shape as the stretcher drawn on plan, as shown in Fig. 12, which may give a general idea of the kind of box used for forming the various kinds of moulded bricks. This boxing may be done in a variety of ways, and there are also a great many schemes connected with the box, such as fixing small pieces of board across the top from one side to the other, and wedging the bricks tight from the bottom instead of the side, as intended by using the box as

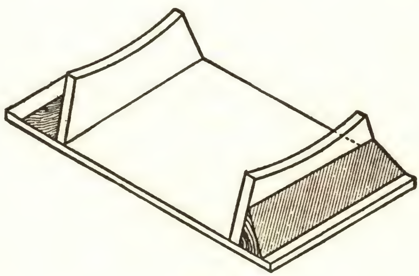


Fig. 12.

here shown; but these improvements are too numerous to mention, and therefore must be left to the ingenuity of the cutter in a great measure.

The first operation in cutting the above is to reduce the bricks to a parallel, either by "bedding" the brick and scribing it to a template, or by bedding it first, and then placing it in a box made with the sides the required depth to suit the thickness of the brick, which is then sawn and rubbed down to it.

It is necessary for proper protection that this box (and all others) should be covered on the edges with narrow

pieces of tin, so as to prevent the wood forming the sides and front of the bottom wearing away when sawing or filing down the bricks. This method is better than having plates of sheet iron cut to the required shape and placed on the sides, for they may wear down without being perceived, and the bricks be thereby moulded out of their intended form; but when there are many bricks worked out of one box, and the tin is worn away, it is soon observed and easily replaced.

Fix about three of these reduced bricks in the box at a time, and wedge them with folding wedges sufficient to keep them steady; then with the bow-saw cut the face and ends of the bricks to the shape of the box and finish with a parallel file.

Take them from the box, and as they are left a little "full," or thicker than the finished size, when first brought down, reduce them by rubbing on the stone to the proper thickness, after gauging the height from the base to the springing of the arch.

The headers, where required to be the full length of the brick, will have to be worked in a separate box deep enough to receive the bricks endways, and of course the width of a brick.

The quoin bricks *b, c* on plan can be cut to templates of that shape.

As the joints in gauged work often appear larger when set than the amount allowed, be careful not to allow too much. Set the work to a template made to fit the semicircle, and also the face of the wall, made something in the form of the inner line of plan Fig. 10. This brings us to the springing of—

THE NICHE HEAD.

It is true that this can be cut without the centre (which method will be given), but it is preferable to show the most practical way first, for if it is possible to cut it without the centre, it is impossible to set it without one, therefore one might as well have it at first as at last.

To form the centre, get two ribs made, the same as the soffit-line required on the face, out of 1½-inch board. Reduce one of these by cutting 1½ inch off the bottom or chord-line, so that if the two are set up together one will be 1½ inch below the other in height; place the

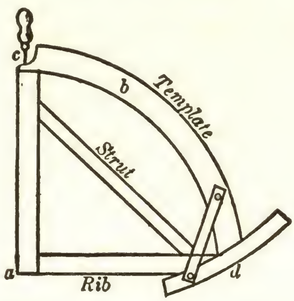


Fig. 13.

smaller one on the bench flat, and fix the one that has not been reduced upright against it. This will make the two semicircles equal, as shown in Fig. 13. Screw them together at *a*; then with some inch board bracket them together so that in section they form a right-angled triangle. But do not fix them to the bench, as most niches are small enough to allow of the centre being used both for cutting and setting the arch. Where this is not the case two must be used. Then with a piece of ¾-inch board make a template, as *b*, with a base and stay to keep

it upright when working, such as a plasterer uses to "horse" his moulds with. Fix this template in the centre, *c,* with a bradawl or gimlet. This will answer as a running mould by traversing the bottom *d,* round the rib lying on the bench. The space between the bracket and the template can be filled up with any solid substance, the lighter the better (say, coke breeze and Portland cement), and finished with a smooth surface with plaster of Paris or Portland cement; this completes the centre. In order to avoid the necessity of cutting the bricks to a sharp point it is usual to form a small semi in plain ashlar

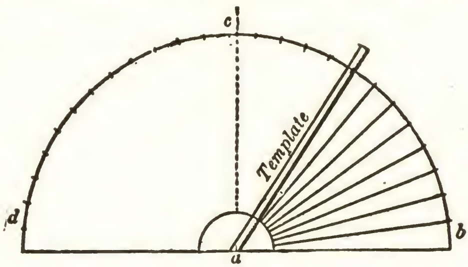


Fig. 14.

at the back of the niche at the springing-line. This is called the "boss," and is struck with a radius one-third of the greater one. But this is optional, according to the idea of the designer and the quality of the bricks; for if the latter are good they can be cut very thin with the bow-saw. Strike the small semi or boss on the centre and mark out the courses of it, if possible, the thickness of those in the body of the niche; draw the face of the arch and divide it out in the usual way, as shown in Fig. 15; then take the width of each course with the compasses and set them out on the front of the centre, Fig. 14, at *d, c, b;* hold the trammel or template (when the "horse"

is taken off) against a nail fixed at *a,* and to the mark already made on the front of the centre, and mark the courses to set the head by.

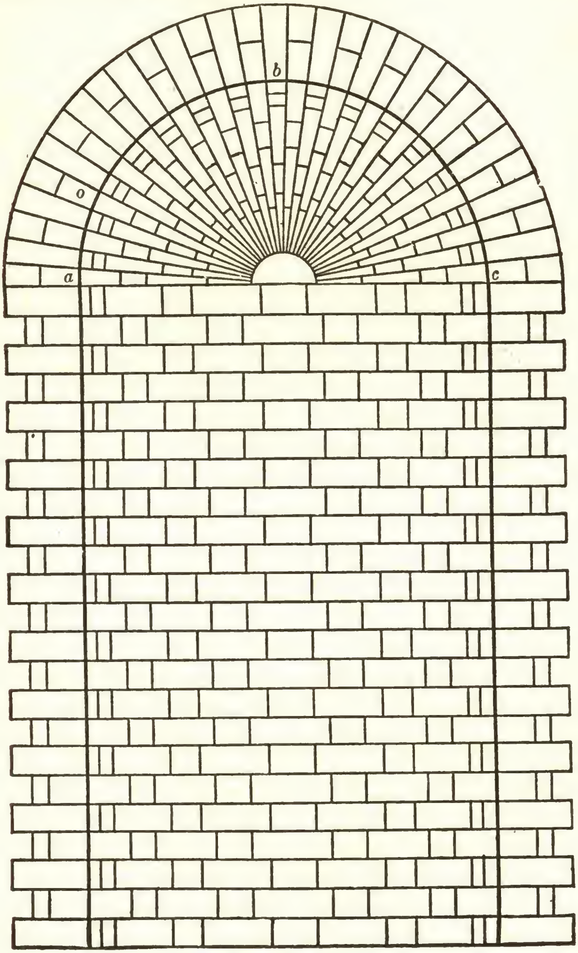


Fig. 15.

To obtain the moulds to cut with, a piece of tracing or lining-paper is stretched on the centre from *a* to *d* or *c*, and fastened at these two points; then with the template mark one of the courses, and as they are all equal one will do for all. After getting a piece of 2½-inch wood cut to the same radius as the arch is struck with (like the template, only square in section), paste the paper that has been marked and cut to those lines on it on the convex or cambering side, as *h* in Fig. 16; the wood can then be planed down on the sides to the paper or lines. This will give the thickness of the course and also the curve of the soffit, as shown in Fig. 17. Set out the bond

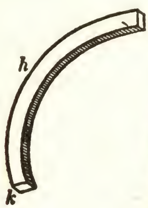


Fig. 16.

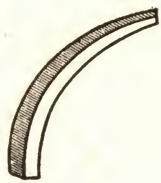


Fig. 17.

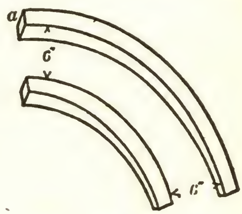


Fig. 18.

on this mould from the face of the arch down to where it meets the "boss" at the springing or back. This will complete the soffit mould.

It is the practice now to do everything possible in good red brick cutting with the bow-saw; therefore, if another mould is made to the same curve, and about 3 inches longer, at the end *k,* so as when placed on the bedding-block parallel with the soffit-mould, Fig. 18, it shall equal in thickness the course at the cross-joint *o,* Fig. 15, this will give the thickness of each course at the back or extrados of the 4½-inch head. After the bricks are moulded in the box (Fig. 12) as before instructed, bring them to

the bevel by rubbing down one side so as to get the proper angle (this is called bevelling the brick from the soffit); fit them in the parallel space between the two moulds, with the rubbed side downwards, saw them down to the box formed by the moulds, and finish them with the file, so that the whole course will be cut at one operation. The face of the niche is cut as an ordinary semi-circular arch.

Another Method of Drawing and Cutting the Niche Head. To obtain the moulds or templates, describe the face of the arch and divide out the courses, as in the

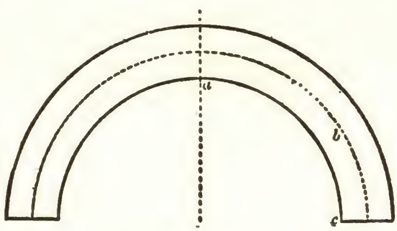


Fig. 19.

case of an ordinary semi-circular arch, so as to obtain the thickness of the course at the soffit-line, *a* (Fig. 19), and measure the distance from *a* to *c*. The former will then be the width, and the latter the length of the template, made in the form of a wedge out of half-inch board. Set off the radius of the semicircle forming the "boss" from the thin end. Then if another mould is made larger in proportion than the first, so as to obtain the radiating thickness of the bricks at the cross-joint *b* (Fig. 19), a box can be formed whereby each course can be cut at one operation, but the bricks must be moulded to the curve as described in the first method. The form of the

soffit is then drawn on the bottom of the box formed by the templates, so that the bricks can be bevelled and laid to this line, ready for sawing and dressing them down. The face is cut in the usual way, and should the niche be a large one the head can be cut in sections.

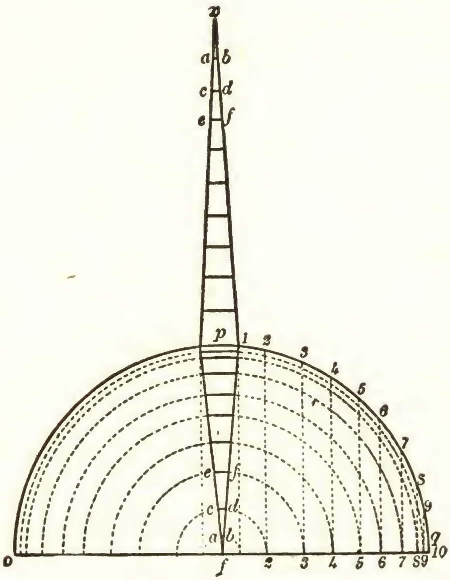


Fig. 20.

Another Way of Drawing and Cutting the Niche Head. Draw the semi *o, p, q, r,* Fig. 20, and divide half the circumference into the number of courses required; continue the perpendicular line to *x,* making this additional length equal to the length of the circumference of the quadrant *o, p;* draw the lines from the two centre divisions on the semicircle downwards to the striking-point *f,*

and also perpendicular lines from the other divisions to the horizontal, as 1, 2, 3, 4, &c.; then from *f* as centre describe semicircles from each of these divisions cutting the lines *p, f;* divide the distance *p, x,* into the same number of parts equally, then *a, b* will equal *a, b, c, d* equal *c, d,* &c., which will give the exact form of the template or mould for cutting the soffit.

The bricks must be boxed and soffited as before described, and reduced to this mould after setting out the lengths required for the bond upon it.

Although these two latter methods are given and are perfectly practicable, nevertheless there is more pleasure in recommending the method first described, both for accuracy and simplicity of working.

THE SEMI-ELLIPSE.

In setting out a niche with a semi-elliptical head there will be found a little more difficulty in forming the centre, and also in the cutting. The centre must be made in many respects the same way as that used for the semicircular niche, and the trammel or template for forming it will be much the same, but resembling that used in forming the quadrant of an ellipse instead of a circle.

In working this trammel round the rib it must not be fixed at the top, but made with a slot to slide on each side of a pin fixed in the centre of the rib, as *c,* Fig. 13, with half the thickness of the template on each side, so that the centre of the template shall be in the centre of the rib; and if the end that is "horsed" is kept close to the rib lying on the bench and the other close to the pin, or nail, fixed in the front rib, no difficulty should be found in forming the elliptical centre.

The courses must be divided out as described for the

semi, and the bond must also be arranged on this centre. The perpends should all carry a line.

The courses of this niche must be cut "rights" and "lefts," as a course cut for the right-hand side will not do for the left, as in the semi.

Each bevel must be taken separately for each course, as it will be difficult to box the bricks, owing to there being two arcs to an ellipse; they must be scribed by the mould and worked singly.

After what has been said about the semicircle and semi-ellipse it will be unnecessary to describe the working of a niche with an elliptical face and a semicircular back, as that seldom occurs. However, if it should do so, the foregoing rules, with a little ingenuity, may be applied to that also.

GROINS, COVES, AND DOMES.

Groins and Coves.

In dealing with groins and coves it is not intended to describe the manner of drawing and cutting all and every kind, as they are so varied, and the ways of working, according to the circumstances of the case, are so different, that it would be an endless task.

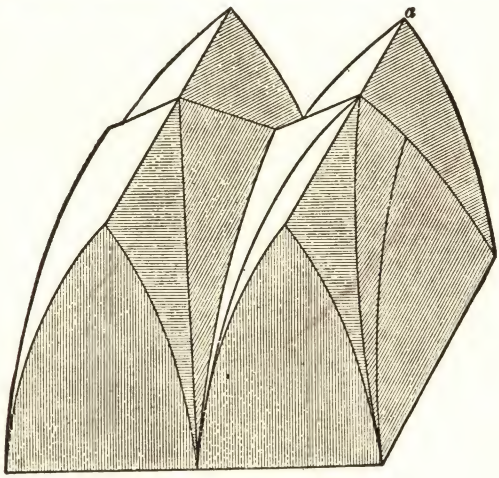


Fig. 21.

But it is the wish of the writer, as far as possible, to give those rules that will apply generally, leaving the workman to use his own discretion in applying them to the particular kind of work that he has in hand.

Groins and coves may be generally classed under two heads—Gothic and Roman; the former, as shown in Fig.

21, is of the pointed order; the latter, as Fig. 22, is simply the intersection of semi-cylindrical vaulting.

The groin point is shown by an external angle when seen from the inside, and the cove with an internal.

If the groins are to be executed in gauge work, great care is needed in seeing that the centre upon which the work is to be fixed is in proper form and perfectly even on the surface, as this is the main guide for turning the vaults and also taking the bevels for the groin point. Any

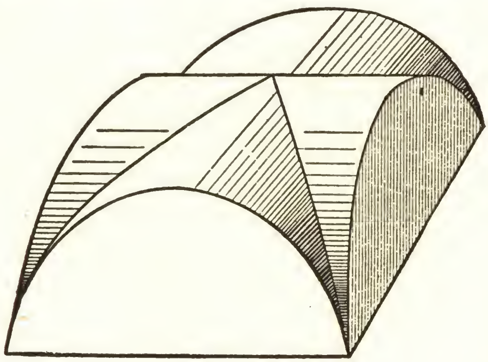


Fig. 22.

irregularities, be they ever so small, will make a great amount of difference in time and also in the quality of the work. In forming the centres to carry the vaults it has generally been found to be the safest and simplest way, where cylindrical or Gothic vaultings cross, to construct one continuous centre first, and after cladding this, let the boards of the second, or crossing centre, cut out at the groin point. For instance, assuming A, Fig. 23, to be a continuous centre, with another of equal size crossing it to form the groin, draw a straight line from the

springing *d, e,* and mark it on the centre A at *f;* let the distance *f, h* equal *d, g,* and with a line fixed at *h,* and held to a plumb rule held upright at *d,* and rising or lowering the line at pleasure, the groin point can be accurately marked on the centre A, and after fixing the ribs of the centre B, cut the boards or cladding to it.

This method will apply to Gothic groins and also to those where a small vault enters a large one, the only difference being that the former enters the latter below

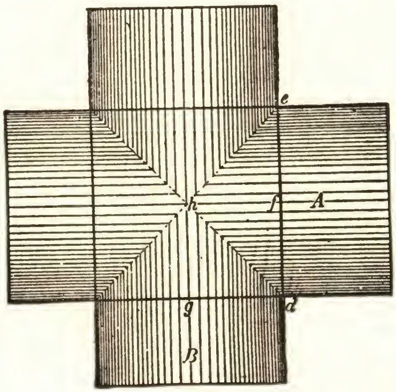


Fig. 23.

the crown just the difference between their respective rises.

When the centres are ready, gauge them over from the top (or key brick) downwards, about what the bricks will be in thickness when reduced, taking care that there is a centre course to answer as key, the same as in any other arch.

Set out the bond from the face or entrance of the vault, so that the broken bond shall be near the groin; for as the work proceeds from the springing upwards, there will

always have to be a rearrangement of the bond in that particular part, and it would be bad to have two broken bonds where one would suffice.

It will be found also that additional perpends will have to be formed near the groin point every two or three courses.

The next and all-important operation is the position for and the best method of taking the bevels, and the method of applying them to the bricks for cutting the groin point.

A great many books have been written on vaults and groins, but we have to look far to find one that will give a practical way of executing the work. After a certain

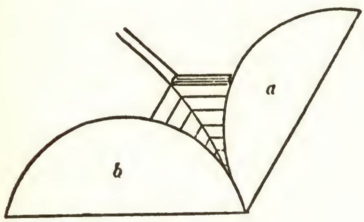


Fig. 24.

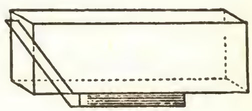


Fig. 25.

amount of information, more or less meagre, has been given, we are commonly told that if we "follow the instructions" no difficulty will present itself. Many of us will have found occasion to doubt this latter statement, and even to question whether some of these writers have tried the experiments they describe. Certainly they will find it difficult to get others to understand by their instructions what they have never carried out themselves.

The first bevel is taken, as shown in Fig. 24, with the side of the bevel laid flat on the centre and the blade up the angle or point of intersection, and applied to the brick,

as seen in Fig. 25. Before cutting the brick, set the bevel as in Fig. 26, with the back to the centre, and the blade set to the angle in a line with the course which the side of the bevel lies against, as shown in the part plan,

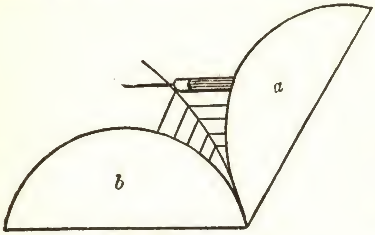


Fig. 26.

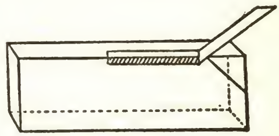


Fig. 27.

Fig. 28; then apply it to the brick, as in Fig. 27, and if cut to these marks, the end of the brick will (if laid on the centre *a* to the lines already marked on it) fit the centre *b* and form the groin point, and be somewhat in the form of Fig. 29.

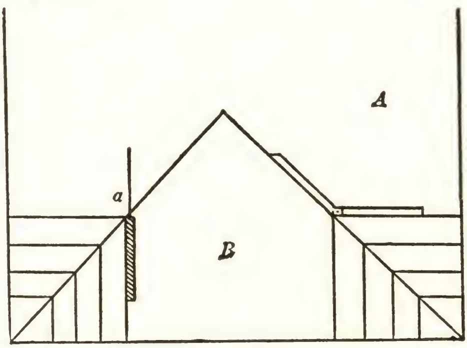


Fig. 28.

Place this brick in the position on the centre at which it is intended to be fixed, and mark the soffit of the end (or the triangular part) to the line drawn for the next

course on the centre *b*, so that when the groin brick is finished it will be something in form like Fig. 30.

There is another brick that is cut similarly to Fig. 31, which bevel can easily be obtained without any instruc-

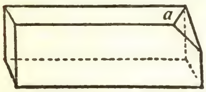


Fig. 29.

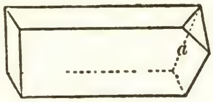


Fig. 30.

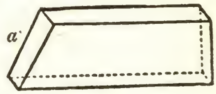


Fig. 31.

tions; this brick is called the skewback, as it supports the groin brick at *a*, Fig. 28. This will complete the first course of the groin.

The second course is taken in the same way, only instead of working from *a* to *b*, work from the reverse,

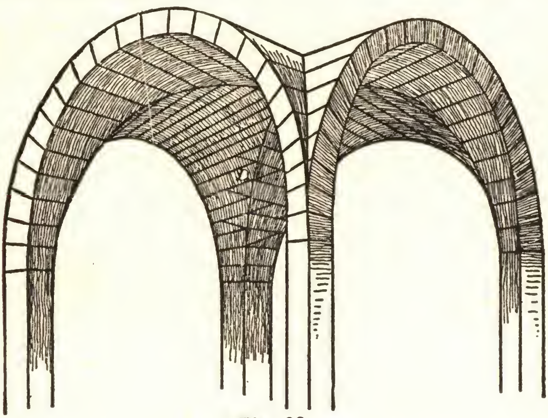


Fig. 32.

from B to A; for in all equal groins the little triangular-shaped end of the brick works alternately, and when looked at from the inside will show a groin point similar to D, Fig. 32, and outside on the top of the groin at D, Fig. 33.

It may be here stated that although the bevels are shown as taken a few courses up the groin, nevertheless this rule applies both to starting and finishing; and not only to this kind of groin, but to every sort, whether Gothic, elliptical, or cylindrical, with the exception of the case in which a small vault intersects a larger one, when it is impossible to work the courses alternately, owing to one arch having a sharper pitch or shorter radius than

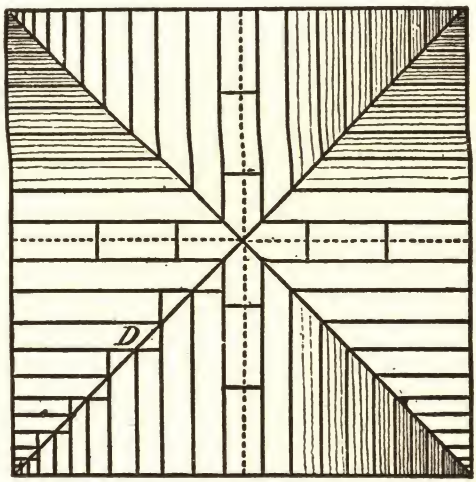


Fig. 33.

the other. And it will be necessary to work two, three, and sometimes four courses in succession one way, until the lines on both centres shall intersect again, and then a reverse brick can be worked.

The bevels for every course must be taken separately, as each has a different angle, although taken in the same way, and the workman will find as he nears the top or

crown of an equal vault that the bevels will become much flatter until they get to a straight brick at the key.

But for the groin as shown in Fig. 34 this rule cannot be followed out; therefore another method is adopted, as shown at *d,* by running the centre courses of the small vault into the centre of the larger one and cutting the ends to form a skewback for the succeeding or upper course of the latter.

It is not unusual in ordinary work, where strength is

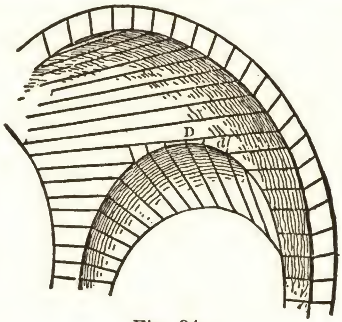


Fig. 34.

the only object, to run the whole of the rings of the small vault unto the greater one's centre, and then work the rings of the large ones unto them; but this could scarcely be called groining.

Coves.

As shown at Fig. 35, coves are at times quite as difficult to cut and fix as groins, as in this case the bricks are cut in an inverted manner—just the reverse of those for groins, and the bevels are taken in a reverse way also.

The courses having been brought to a uniform length and thickness, and tapering toward the soffit according

to the radiating lines of the sectional curve, set the bevel to the angle *a, b, c,* Fig. 36, with the side of the bevel flat on the wall or pier from which the work springs, and

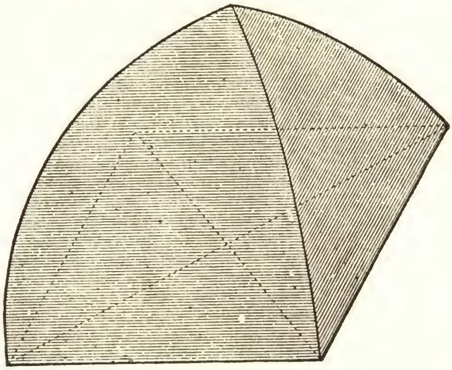


Fig. 35.

mark the brick, as Fig. 37; square the lines from the face (or that part that goes next the centre) to the same distance from the face as the brick is supposed to overlap the cove point, as at *e,* Fig. 36, and cut out the parallel

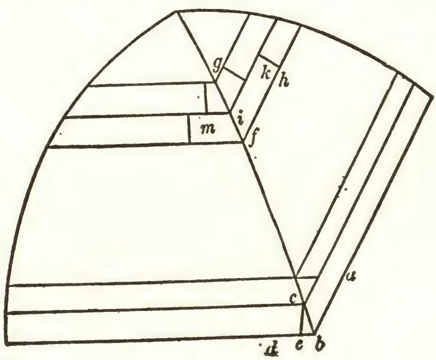


Fig. 36.

piece so that it will resemble Fig. 38 when finished. This will give the angle of the cove, and if placed in its position in the centre, will show where it is necessary to further cut the projecting end *d*, so as to fit close to both sides and also form the triangle as seen from the inside.

This brick, when finished, will, according to its position on the point of the groin, somewhat resemble Fig. 39; but every course that is cut from the springing upwards will be slightly different from the one before it, as also will every bevel taken be at a different angle, beginning with a right angle and finishing with a very sharp acute angle at the key; but all are taken in relatively the same position. It will be perceived that no bevel is given

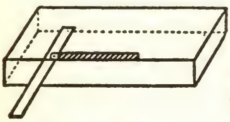


Fig. 37.

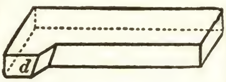


Fig. 38.

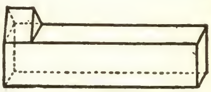


Fig. 39.

for the angle *a, b, d,* Fig. 36. The reason of this is the difficulty in getting the bevel into the angle as the work gets up, owing to the radiating of the rings. After the angle or cove brick is bedded, take the bevel *d, e, c,* Fig. 36, to cut what is called the skewback brick, and after arranging the bond, the first course of the cove can be completed. The second course simply requires to be worked to the other hand, as in the case of the groin point, only in an inverted form.

Another way of bonding the angles is by cutting what is called the "bird's mouth," and by many it is considered to be by far the best way and superior to the preceding one, owing to the greater strength in that particular part, as by reducing the stretcher that overlaps the angle it is

obvious that the strength must be greatly reduced; whereas in the case of the bird's mouth (even if it is necessary to lay the brick flat for a few courses near the top to obtain the proper bond on the soffit), it is only half the amount in area, as the bird's mouth is cut with a half brick and the stretcher (in the other way) with a whole one.

This method is shown in the upper part of Fig. 36, and the brick which forms the bird's mouth is something in the shape of Fig. 40.

To obtain and apply the bevels for the first course in this method, place the stock at the line *f h,* Fig. 36, and the blade up the angle *f g;* mark this on the brick sufficiently far from the end to allow for the other bevel to

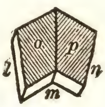


Fig. 40.

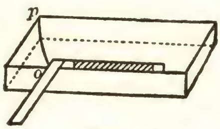


Fig. 41.

work to form the mitre, which, if the cove is at right angles, will be half a right angle, or 45 degrees, at the springing, and will gradually get wider as it nears the crown; this is marked on the brick from *o* to *p,* Fig. 41. If this is cut and the same operation performed (with another brick) the reverse way, it will complete the first course.

The second course, or bird's mouth (if the courses are not gauged out too thick), can be worked out of the end of a full-sized cutting brick, not one of those that have been reduced for the rest of the work, as they will be too thin; and even the full size will not be thick enough for more than about one-third of the way from springing to

crown, and then they must perforce be cut out of the brick flat ways to hold out thick enough at the cross-point where the adjoining brick meets the bird's mouth.

To work the bed, or side of the half brick *o, p,* Fig. 40, is the next operation. Straighten the soffit and make a saw groove in the centre, and straighten the back and mark the upright line, as shown between *o, p.* Do not attempt to cut the soffit until after the bed is worked. Set the bevel to the angle K, I, *g*, Fig. 36, and lay it on the soffit of the brick so that the blade lies along the centre line; mark on it and then scribe along the stock. This will give the bevel for one side; serve the other side the same and cut the brick; this will form the angle for bedding the brick on both sides of the point. Then from this bed angle make the soffit parallel; this will form the angle for the mitre that follows.

The soffit angle is cut from the bevel *m,* I, K. Lay the stock on the centre with the face downwards and bend the blade over the point as close into the angle as it is possible to get it, and scribe it equally on the bed of the brick; or set the stock upright with the point of the cove with the blade on the centre, and scribe the brick by placing the stock on the line running between *o, p,* Fig. 40, and reverse it for the other side.

The remaining angle is taken by placing the back of the stock in the angle formed by the preceding course and the blade up the cove point; this will give the soffit as it goes towards the crown.

The wedge shape is easily obtained by placing a brick, dry, on either side of the bird's mouth on the centre, taking care they are laid to the bond previously marked thereon.

Rib and Panel.

There is also another kind of vaulting or groining which is called rib and panel; and the bricklayer has sometimes to execute a great portion of this kind of work, although the springers, ribs, and centre boss are usually of stone and fixed by the mason. Nevertheless the panels are worked in with plain or gauged brickwork, and very often the centre ridge, as at *a*, Fig. 21, is worked almost in the same manner as the lower part of Fig. 36, and the method of taking the bevels for the one in a great measure applies to the other; only in this case it is not usual to run the courses of the vault parallel with the springing line (as in the case of one that is not panelled), but in an oblique direction.

The author can scarcely expect the reader to follow him in all the minute working of groin-cutting by simply reading what he has written. For in bricklaying, groins and coves (when taken throughout) are the most difficult of all branches to work correctly. It is hoped, however, when the reader has the work in front of him, and is thus better able to appreciate what has been said, that the general principles here given will assist him, and that he will have no difficulty in bringing his work to a conclusion equally satisfactory to his employer and to himself.

Domes.

Where towers, &c., are circular on plan, and it is desired to form a covering or roof to them in brickwork, as groining is out of the question, doming is the method usually adopted.

To enable the cutter to execute this kind of work the centre must be placed in its position, and the courses

marked upon it. Now, as the bricks at the extrados or outside of the dome are required to be much thicker than those at the soffit, therefore to avoid the great waste of material that would ensue if it were turned with headers the full length (as they would have to be kept so thin at the soffit), it is more economical, and the work is quite as sound, to dome over by 4½ inch rings, which

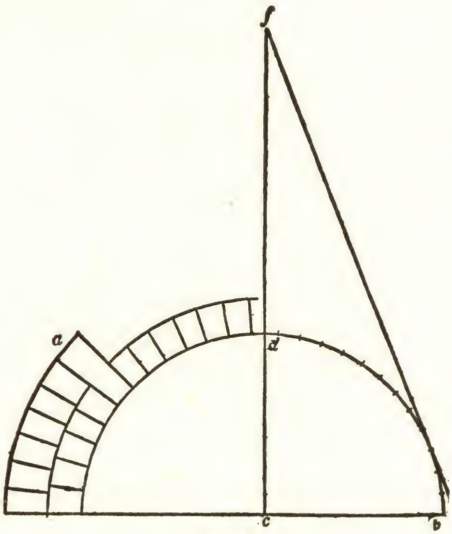


Fig. 42.

can easily be bonded one to the other wherever the inner and outer rings coincide, as at *a,* Fig. 42. This may occur more than once, as the rings rise upwards. Another advantage of this method is that the outer rings may be turned with stocks or any hard and sound bricks, which will make the work much cheaper.

Gauge the centre over with a gauge-rod, as shown at

b, d, taking care to gauge from the crown downwards, and erect a staff through the centre, at *d,* fixed to a ledge at the chord or springing line perfectly upright, and with a trammel fixed at the point *f,* for instance; then bringing it nearer to the crown to suit the small circles, mark the courses all around the centre. This will give the rise.

The bond should then be equalized out at the springing, so that all bricks in a course are equal, and lines drawn on plan, Fig. 43, for taking the bevels, and also for a guide line for the perpends, which should carry a line from springing to crown; but as the bricks would eventually cut out to a point, it is usual (where there is no opening) to have in the centre a base or circular keystone so as to prevent this, otherwise the bond would have to be rearranged every six or more courses as the work proceeded.

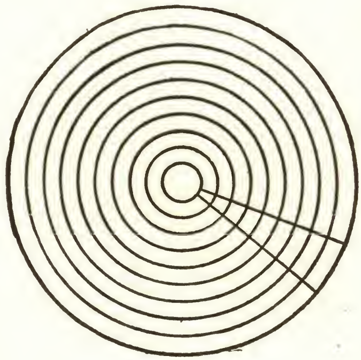


Fig. 43.

Doming for Lime Kilns.

There is another kind of doming which is almost exclusively used in the construction of lime kilns; and although it does not require nearly so much accuracy as is necessary for gauged work, it may be worthy of notice. The kilns are greatly used in Kent, about Rochester, and are mostly built of firebricks. They are in the form of an oval or ellipse, and the arrangement of the body varies to suit the requirements of the proprietor or lime-burner, but in every case the top is domed over, and so domed that the longest diameter shall be equal

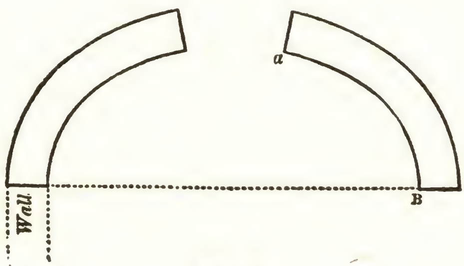


Fig. 44.

to the shorter one at the top; or, in other words, the dome finishes with a circular chimney opening, upon which is built the chimney shaft.

It is generally considered a disgrace to the builder if he has to cut any courses out at the ends to obtain the required form at the top, therefore it is desirable to see how each course will work all the way round and yet meet in the circle at the top, more especially as it is no easy matter to cut out courses with firebricks as a building material. These domes are turned without any centre to work upon, so that a respectable latitude is

given to the discretion of the workman, as the only guide he can obtain is at each end and each side, where a pliant gauge-rod can be used.

To obtain these rods, strike that portion of the dome from *a* to *b*, Fig. 44; divide the length out into courses and mark them on a pliant rod that will bend to the required curve; and if anything in the form of a staff is fixed at the height of the proposed chimney to which the rod can be secured, and a nail driven into the wall at the springing B B, for the bottom of the rod to stand upon, this will correctly guide the builder at these four points. But everything depends upon the fixing, so that the end of the rod meets the position of the finishing circle at one end and the nail at the other.

As the work proceeds the sides will not gather over nearly so fast as the ends; neither will they be so high (if a longitudinal section were taken when the dome was half turned, it would be almost in the form of an inverted semi-ellipse); and the bricks also at the sides will assume more of a horizontal position than those at the ends.

COLUMNS AND WALL WORK.

Columns and Pilasters.

Where cylindrical or diminishing columns are cut in gauged work it is necessary to draw the plan full size and set out the bond, so as to obtain the exact form of each brick, which in this case should be equal, and if the column is anything under 12 inches diameter it can best be cut and set in the shed—always provided there is room.

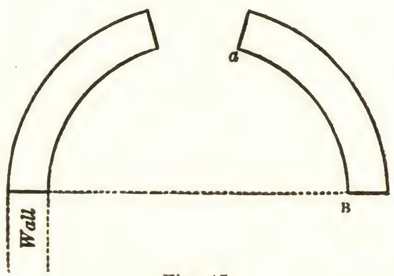


Fig. 45.

A box must be made as before described in working the bricks for the niche, only this time the section or side of the box must be in the form of *a,* Fig. 46, even if the column is diminishing at the top. When under the size given it is better to cut the whole of the bricks to one box, and to set the work in the form of a cylinder, it being then much easier to dress off the diminishing part when fixed in the "reel." It is necessary also for strength and for accurate working that a die square rod of iron should pass through the entire length of

the column, projecting out about 2 inches at each end. The thickness must in a great measure depend upon the size of the column, but take care that it is not too thin.

This iron should be made round at the parts that project beyond the ends of the column, and will then answer three purposes, viz., strength, dowels, and also as a spindle for turning the column in the reel.

This reel is composed of two pieces of plank made in

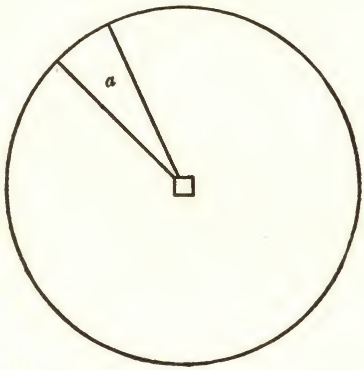


Fig. 46.

the form of *a* and *b,* Fig. 47. Fix securely to the bench, at a little more than the length of the column apart, with a hole in one and slot in the other large enough to receive the iron running through the column, taking care that the centre of the hole is exactly half the diameter of the end of the column (when finished) below the top of the reel at *c d,* and when the turning is complete both should be level.

The black line, *e f,* is a rule fixed to the reel level with the top, as shown at *e f,* and parallel with the

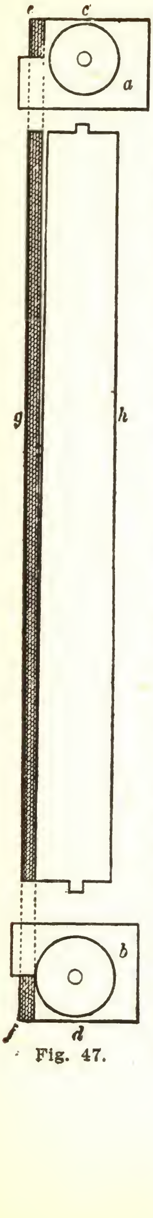


Fig. 47.

centre line of the column on the side or front nearest to the workman, perfectly upright, so that when the square is applied to the face *g* across the column to *h*, it will show what is necessary to dress off when it is being turned; or instead of using the square fix another straight-edge on the side *h*, level and parallel at each end with the one already fixed at *e f*, and so by holding the parallel file across from one to the other as the column is being turned the work can be brought to its proper form.

The column ought to be set out, and the bricks cut larger than the finished size, so as to allow for irregularities in setting and for dressing off.

The latter process is performed with the file first, and afterwards sandpaper on pads of woods, or anything to keep it straight on the surface, otherwise the work will be rubbed in hollows in some places.

For setting this kind of work, as also in the case of all kinds of volutes, caps to columns, or any kind of work that is to be carved after it is put together,

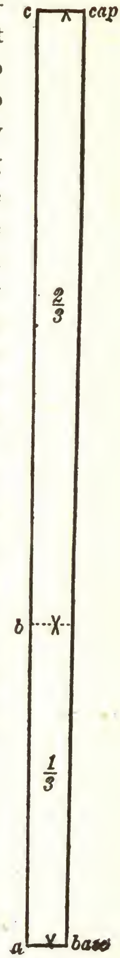


Fig. 48.

patent knotting and powdered white lead should be used.

These are mixed up on a slate or stone slab as required, to the consistency of a cream, and after the brick has been dusted with the dry brush, and slightly damped, spread a thin layer of this cream upon it, and rub the brick down as close as possible to the preceding one, in the same manner as a carpenter does a glue joint.

This mixture will set in a short time, and is the hardest and most convenient fixing material known in the trade. When cleaned off it is very neat, and the joints are so small that in cutting the work nothing must be allowed for them, but the brick must be cut to the full thickness of the course.

The iron rod before mentioned should be fixed (when the work is ready) top and bottom perfectly upright, and the work set to it, then all will form a solid body that in two days can be moved, turned, and fixed.

If the column is of greater dimensions than 12 inches, the bricks must be boxed in the same way, and these fixed with putty in the position it is intended to occupy, as it would be unwise to attempt to turn it in the reel.

The setting should be done with four diminishing rules, securely and correctly fixed top and bottom, surrounding the column at equal distances apart. By a diminishing rule is meant one that is upright on the edge that faces the column for one-third of the height from *a* to *b,* Fig. 48, and overhanging for the other two-thirds, so as to make the column battering from *b* to *c,* to the extent of half the difference of the top and bottom diameters, which in Grecian architecture is as 50 or 52 is to 60; that is, if the bottom diameter is divided

into 60 parts, 50 or 52 of these should be the diameter of the top.

If the columns are to be fluted, the circumference of the bottom, of one-third up, and top of same—that is to say, the part not battered—must be divided into the required number of parts according to the desired size of the flutes, three parts being given to each flute and one part to each fillet between the flutes. These must be marked in after the work is set, by the aid of straight-edges. In this case the work must be squared in from the face, *i. e.*, cut solid as far in from the face as necessary, so as to avoid cutting into unsound work when working the flutes.

Pilasters.

For pilasters the method of working is altogether different. The plan, elevation, and sections should be drawn on a board to the full size, the courses gauged on the elevation, and the bond set out on the section.

A box should then be made by taking a tracing of this section, and pasting it on a cleaned piece of board from which the box is to be made, and when dry, cut the board to the traced lines.

If the pilaster is not to be diminishing, two of these sections (one for each side of the box) will be sufficient, but if diminishing, this will only answer for one third of the pilaster from the base upwards (for the same rule as to diminishing applies to the pilaster as to the column); the other or battering part must be taken at stated distances above the upright part, and sections made to those parts. If the box is made as before described, with the sides square with the bottom, so that the bricks when placed in it shall stand upright, and

also of the depth to receive the bricks, four, five, or six courses can be fitted in, wedged, and conveniently worked by the aid of the bow-saw and gas barrel at one operation.

In setting out the bond, if possible, let all cross joints be in the fillets, as they are straight on the face, while the flutes are circular, and the cross joints, if made in

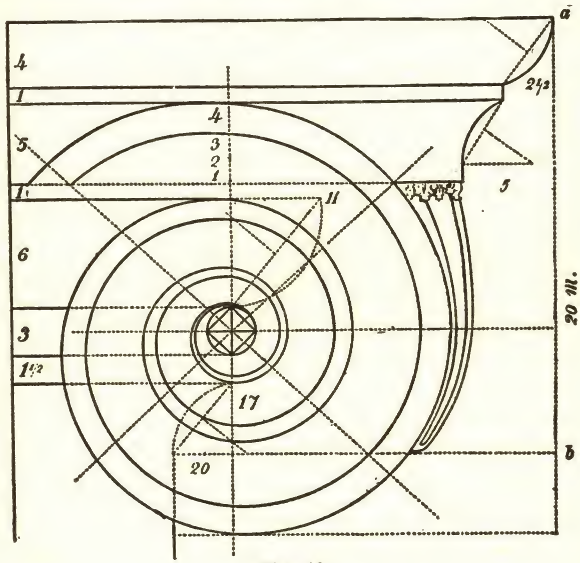


Fig. 49.

them, will have the appearance of being a great deal larger than they really are, and will also look thicker than the bed joint, which ought not to be.

Volutes, Scrolls, &c.

The various methods of describing scrolls and volutes are almost too numerous to mention, but it is intended

to give a few general rules, which the reader, it is hoped, will have no difficulty in adapting to particular circumstances.

It is seldom that they are executed in brickwork for capitals of columns, but they are not unfrequently used for pilasters, frontispieces for doors and windows, pediments, &c., and of these perhaps the Ionic is the most difficult, and at the same time the most beautiful.

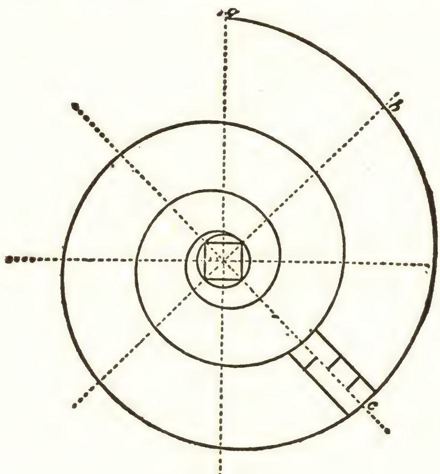


Fig. 50.

Fig. 49 represents the volute for a modern cap of this order with mouldings attached, also giving the proper depths of each separate moulding, and the distance that each should be set back from a plumb-line held to the extreme part as *a b*, taking the diameter of the base of the column or pilaster as being divided into 60 parts; for instance, if the diameter is divided into 60, take $2\frac{1}{2}$ for the top *a*, five parts for the second, &c. These parts,

with the plan Fig. 52, give the proportionate size of the volute.

The manner of describing the above is given in Fig. 50, of which Fig. 51 is the eye or centre square enlarged, from which all the parts are described. Draw the cross tree and bisect each quadrant so as to form eight equal parts, form the square for the centres a twelfth of the whole depth the volute is intended to be, and let the angles of the square be on the horizontal and

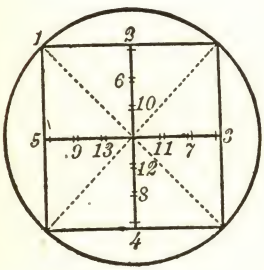


Fig. 51.

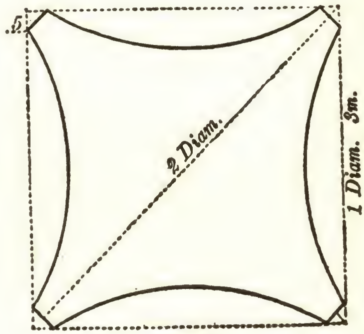


Fig. 52.

perpendicular lines as shown; then, with the largest radius beginning from the position shown, with 1 as centre, describe that part from *a* to *b*, Fig. 50, and with 2 for centre that part from *b* to *c*, &c. The first part is only an eighth, but all the other parts are quadrants, until the circle is met in the middle.

The double dots on the cross lines of the square are for drawing the second or inner rings, and are followed in the same order as the first.

In cutting volutes, the full-sized plan of the cap at the top, where the volute touches the moulding, should be obtained, such as Fig. 52, the form can then easily

be obtained. The work is cut and put together in the cutting shed with patent knotting and lead, as before described.

It is very difficult to cut the bricks singly to the forms required, therefore they are generally put together in a solid block, somewhat near the shape required, but at all events quite large enough, and the bond so arranged that the perpendiculars are upright on the end, and also on the sides where they do not work out. Let the bond be set out from the greatest projection, as shown at *c*, Fig. 50.

After this is done and the work is set hard enough,

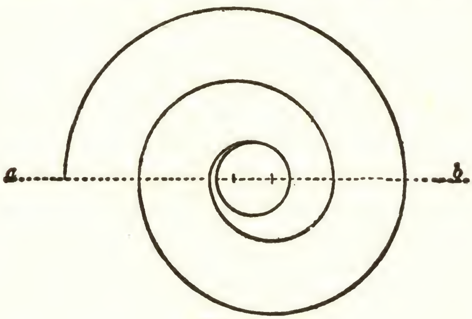


Fig. 53.

cut the sides down to the form of the angle of the plan, and dress them off with the file; then, having the side elevation, as Fig. 49, traced off, paste it on these sides, and cut to the lines through the paper for the outer curves; the remaining lines will answer for the sinking. If there are a great number, instead of pasting the tracing on the work put it on a sheet of zinc and cut the latter to the shape. It is then only necessary to lay the zinc mould on the volute, and scribe round the curves and cut to the lines with a bow-saw.

When fixing the above in position on the pilaster, there will be some little difficulty in arranging the mouldings where they join the volutes, but this cannot be described. All it is necessary to say is, leave plenty of stuff on the end that rests on the cap, so that there is enough "tailing," and also to give a better opportunity of working the mitres with the moulding. Assuming the diameter of the volute to be 20 parts, or one third of the

Fig. 54.

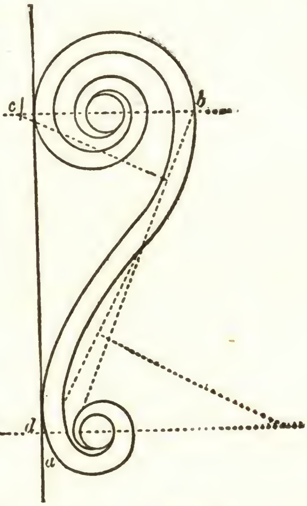


Fig. 55.

diameter at the base of the pilaster, let the length from front to back be 35 or 40 parts.

Fig. 53 gives a simple method of describing a scroll from two points on a straight line *a b*. The longest diameter of the scroll having been obtained, take the centre as the first striking point, and make another point or centre one fourteenth part of the diameter farther to

the right-hand, and describe the scroll by semicircles alternately from these centres.

The method of blending these scrolls into trusses is shown in Figs. 54 and 55. The chord line is drawn from *a* to *b,* and bisected for the point of meeting of the two arcs, after which each of these parts is bisected in like manner, and lines *c* and *d,* perpendicular to the horizontal or chord line *a b,* are drawn through the centre of the scroll, from which two centres the con-

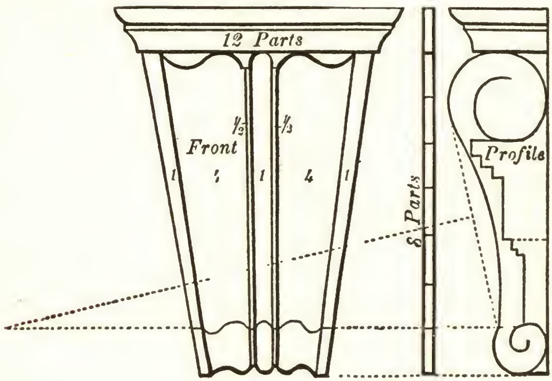


Fig. 56. Fig. 57.

necting lines of the scrolls are obtained by either of the foregoing rules.

Fig. 54 shows the front elevation and the proper manner of dividing out the flutes and fillets. The same rule as regards the cutting and fitting applies to the truss as well as to the volute, and (it may be said) with very few exceptions, to every kind of scroll.

KEY BRICKS FOR ARCHES.

These are frequently cut in brick and afterwards carved to beautiful forms, both on the face and side

elevations. Figs. 56 and 57 give a general rule as to the proportions usually adopted when setting out the arch.

When cutting it is unnecessary to cut the top moulding at the time the key is blocked, but work the two separately, and always cut the outside plain to the required size and form the sinkings afterwards. Put it together in courses, as in the case of the rest of the arch, only on the bench, instead of setting it on the centre, and let the bond begin at the soffit and work upwards. When set, and hard enough, carve the sinkings as before described by means of tracing paper, always working from a centre line.

The reader cannot be too earnestly impressed with the importance of leaving all work for carving of every description solid, or in other words, each brick must be well squared and jointed in beyond the depths of all sinkings, particularly if the carver is to work upon it, for when he does he is generally unmerciful as to how he strikes it with his chisel and mallet, and if there is not depth enough of solid work it will, when finished, have a very unsightly appearance, owing to the irregularities of the joints, &c. The evil effects of this are frequently seen, and when dressing down the work it is then necessary to use stopping to give the work something of a respectable appearance, but this cannot be too much condemned. Gauged work is considered the greatest of the arts connected with the handicraft of the bricklayer, and is principally employed in buildings for its beauty; and if this is destroyed by inferior workmanship, the proprietor, architect, and builder have alike failed in their object, and the result is a standing disgrace instead of an honor.

PROPORTIONS OF DOORWAYS.

To proportion mouldings, &c., and also to obtain the proportionate size of the opening, divide the opening or door into six parts (see Fig. 58). Give one of these to

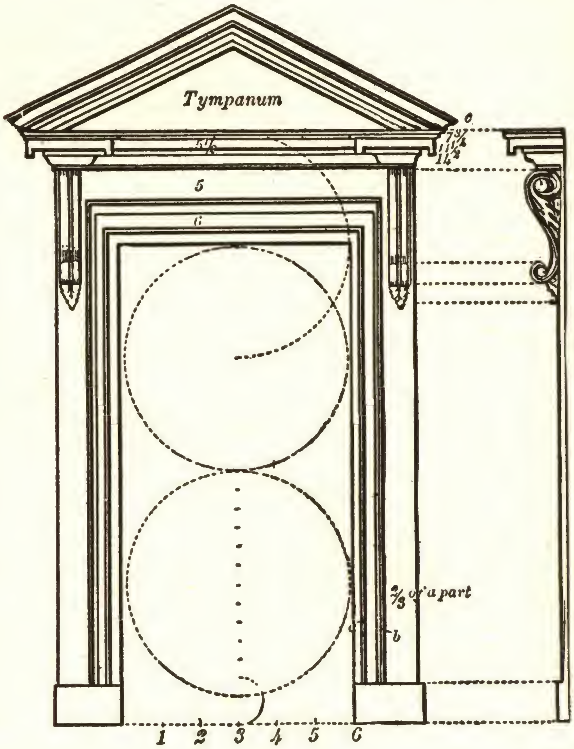


Fig. 58.

the architrave, and by dividing this into three parts one will give the width of the first member or knee as *a,* and two for the other part or open pilaster *b,* and for

the height of the architrave, frieze, and cornice half the width of the opening. This is seen by the dotted circles.

The plinth is one-sixth of the opening in height, and the truss is half the width of the opening, and two-thirds of one of the six divisions of the opening in width. The height of the doorway should be 2 1-12 diameters.

For the architrave, frieze, and cornice above the door, divide the architrave into six parts; give five of these to the frieze and five and a half to the cornice at the base of the tympanum, or seven parts to the top member at the springing of the pediment. Sometimes five and a half parts are given to the frieze and six and a half to the cornice.

It would be out of place in this little work to enter into the projections of all the various mouldings, but for the cornice of doors it is usual to divide the latter into 40 parts, and each moulding is set back from a plumb-line held at the extreme point *c* (Fig. 58). In this case to the fillet of the first moulding is 7¾, the face of the corona 11½, and the top member of the cap of the pilaster 14 parts.

Fig. 59 represents a doorway with proper proportions given for setting out on a large scale.

In this case the diameter of the column rules each part, and the dotted lines show the centre for striking the arch.

The bricks for these columns, when diminishing, should be boxed in boxes that diminish with the column, and should be taken in sections to save making so many boxes. Let the column be divided into three parts, so that one end of the box is a section at 0 and the other at 1, the next sections 1 and 2 respectively, &c., and by

keeping each brick or course in its proper place it can be set as the other work proceeds. The arch and head mouldings should be fixed together as before described and fixed as one block.

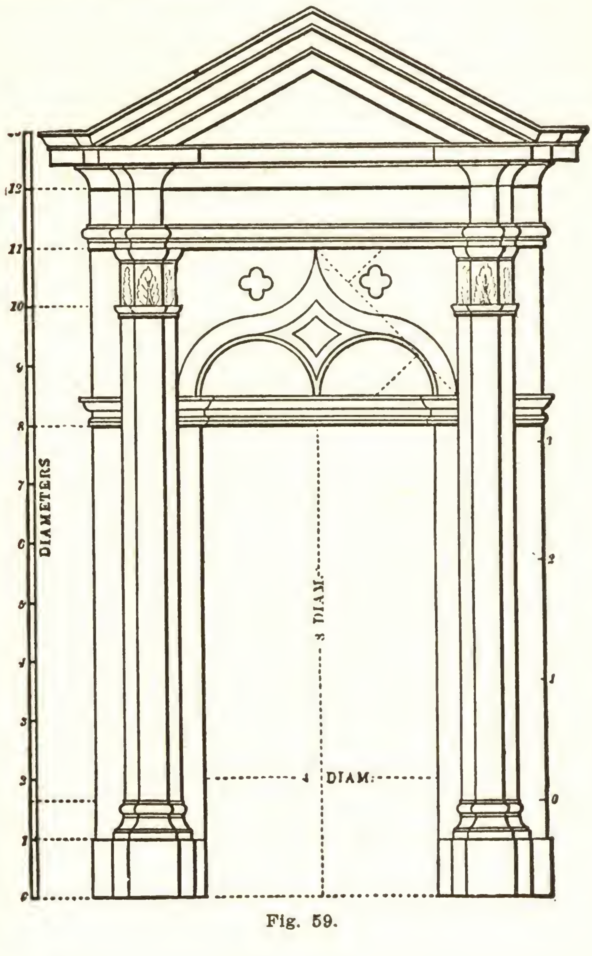


Fig. 59.

Pediments.

Four different kinds of pediments are given in Figs. 60 and 61. To describe the first (A Fig. 60), draw the chord line *a b,* and divide it into three equal parts, and the centre one of these three again into six; draw the dotted line *c d,* from the second division, also the line *a d,* which will give the striking point for the part *e c;* then draw the line *d c f,* and erect a perpendicular at *a* to *f,* which with *f a* as radius, will describe the part *a c.* The scrolls must be described as before directed.

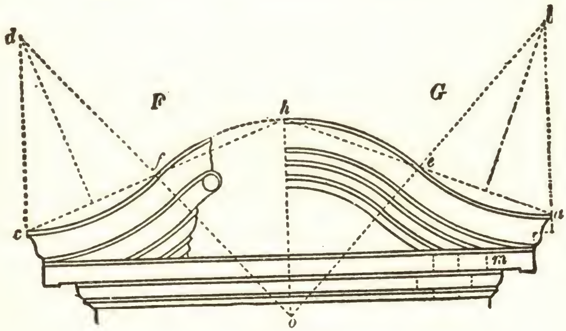


Fig. 60.

If the upper curve is to rise above the chord line, take the striking centre farther up to the point *g,* with radius *g c,* for the arc *a c* and lengthen the radius from *d* to the division *c* for the upper portion.

For the half B, draw the chord *i k,* and divide it into four equal parts, and draw the lines *h n* and *l m* at right angles with it; erect the perpendiculars *i m* and *n k,* and where they intersect at *n* and *m* is the center. F and G, Fig. 61, are treated in much the same way; each chord line is divided into four parts, and perpendiculars erected

from the second and third division, cutting the perpendiculars *a b* and *c d* at *d* and *b,* which are the centres for those parts, and with the lines drawn through the centre of the chords from *d, b,* to *o,* will give the latter as the remaining centre. The radius in each case will be either *d, b,* or *o,* to where the lines cross at the point *e,* or *f.*

For the moulding at the sides of the pediment at *a,* the angles of the dotted lines are the centres for striking the arcs.

In arranging the bond for all cornices, the extreme

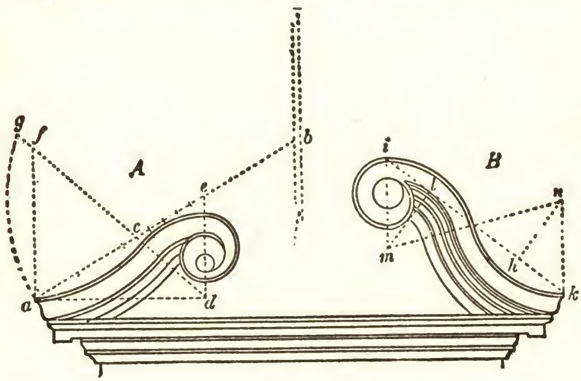


Fig. 61.

point as *m* whether header or stretcher, ought to be a whole brick, and if a three-quarter is required let it be in the lower or starting courses.

In cutting the circular courses for the pediment head, the file will answer for the face of the moulded brick only, and to obtain the circular top and bottom, it is necessary to rub the bed of the brick and place it in an oblong box, the width and length of the brick in the clear, and about an eighth of an inch deeper than the

course is required when finished; then take a piece of iron ¼-inch thick, 1¼ inch wide, and about 2 feet long, straight on each edge, and after bending the flat side to the curve of the pediment, work the brick that is in the box so as to form a concave or hollow face upwards. Then take the brick from this box and place it in another one, an eighth of an inch less than the former in depth or the finished thickness of the course, and with the sides made to a section of the finished brick, and place the concave face downwards; then with the other side of the iron bar work the convex or cambering side and also the mouldings on the bed, but finish the brick straight on the face of the moulding with the file. This brick when cross-jointed to the radiating bevel, and taken to the width to suit the bond, will correctly work the heading course from *a* to *e*, Fig. 61. As the majority of courses for circular pediments are heading courses, nothing need be said about stretchers.

The remaining part, from *e* to *h*, is worked in like manner, only the order of working is just the reverse: the convex side is worked in the first or reducing box, and the concave in the moulded one.

The return *a* is worked without a box, simply by reducing the brick and drawing the small quadrants on the side (or by a mould previously made) and working to these lines, square from the face. When pediments are open, as Fig. 60 and F Fig. 61, it is usual to place shells, busts, or the like; and sometimes a miniature pier and cap is erected, so as in a measure to fill the void that remains if left open. The closed circular pediment, as G, Fig. 61, is often surmounted by a vase or ball, and whether this ball is a sphere or spheroid, it is necessary that it should be perfectly true to the design.

MOULDINGS AND CURVILINEAR WORK.

The Globe or Sphere.

In cutting the above, equalize the courses out, so that each course when finished is equal in thickness and exactly fills out the required diameter. If the ball is to be a foot in diameter, build a cube block a foot each way, remembering to set out the bond from a perpendicular line in the centre, and let the bricks die out each way; and in this case, if the bricks are cut to 8 inches by 4, the bond will work out the foot much better, so that each course will be composed of three headers and two three-quarters worked alternately.

This block should be built solid, with all bricks squared in and set with knotting as before described. When it is hard, say in a day or two, describe a circle at the top and the bottom from centre lines, and with the bow-saw cut the corners off, so as to form a cylinder, always keeping the courses the same way up as they were built, taking care to leave something on, full of the lines, for dressing off when the turning is done. Then drill a hole through the centre of the courses perpendicularly, and place a ¾-inch rod of iron through it, so as to project out on each end (this can be fixed temporarily with a little plaster, or any fixing substance), so that it will answer for a spindle. Then have a box made about 14 inches square on plan and about 8 inches deep, and sink the spindle down about an inch from the top at each end, just so that the cylinder will turn easily; then, if two pieces of board are obtained about a foot square, and the

ends cut in a form of a semicircle the same diameter as the ball .these can be fixed opposite each other on each side of the box, and if they are kept six inches above the centre of the spindle and perfectly level at the top and square across, they will show what is necessary to cut off the block with the bow-saw. Then a file held across while the ball is being turned will be a safe guide to bring the ball to its required shape. The iron bar can be driven in at one end, and by letting the projecting end into the pier or pediment head, serve as a secure fixing. Cut the hole square at the top and sink in a piece of brick and work it off.

Mouldings.

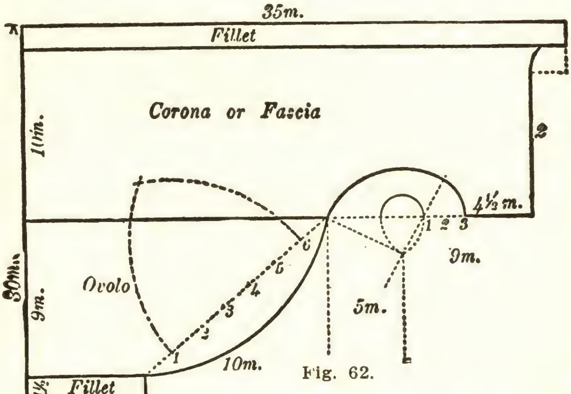
It is not thought out of place to give a few general rules for describing the various mouldings commonly used in gauged work.

Fig. 62 gives the corona, ovolo, and cavetto of a cornice of the Tuscan order, with the proper projections and proportionate heights. The chord-line of the ovolo is divided into six parts, of which one is set off at each end, and the dotted arcs drawn by the compass serve to obtain the centre for drawing the ovolo from, which will be at their point of intersection. The cavetto is described from the point where the perpendicular line drawn from the centre of the chord meets the horizontal line at *a*.

Fig. 63 is the part that springs from the base of a column or pilaster, and the arc is drawn from the chord-line, taken from six parts up the perpendicular and five parts on the horizontal, as shown by the dotted lines.

The scotia (Fig. 64), which really belongs to the base

in the case of columns, is drawn by dividing the height between the fillets into seven parts. From the fourth division *a* with *a b* as radius, describe the arc to *c*, and draw the rectangular dotted lines meeting at that point. With *c* as centre and *c e* as radius, describe the dotted



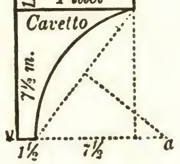


Fig. 62.

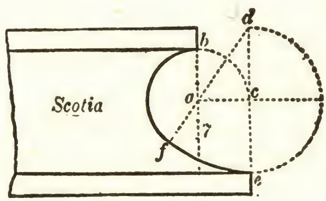


Fig. 64.

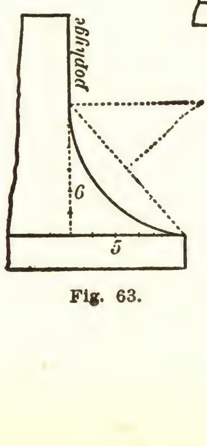


Fig. 63.

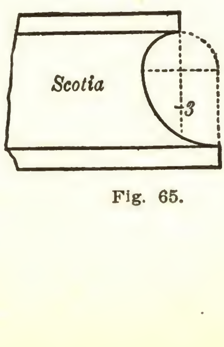


Fig. 65.

semi, draw the line $d\ f$ through a, and d is the centre for that part from f to e, and a the centre from f to b.

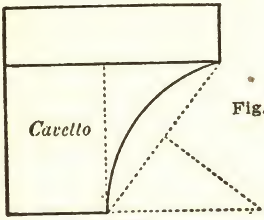
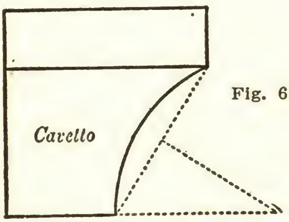


Fig. 66.

Fig. 66.



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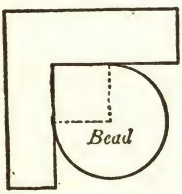

Fig. 68

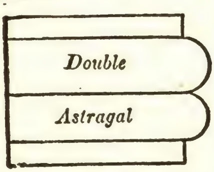

Fig. 69.

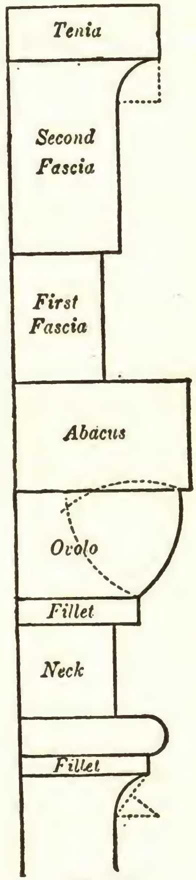

Fig. 70.

The second scotia (Fig. 65) is divided into three parts, as figured, and described as the dotted lines show.

The cavetto and four following figures need no further description than what has already been given, as they are plain to observation.

In the case of the regula, cyma, recta, and fillet (Fig. 72), the chord is divided into fourteen parts. Setting off one at each end and two in the middle will give the radii and centres for striking, as shown by the dotted lines.

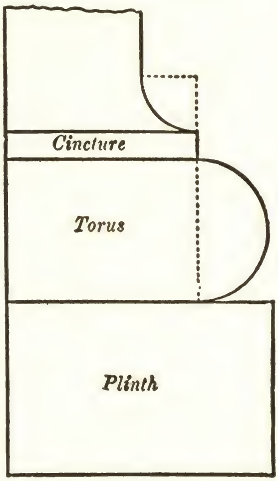

Fig. 71.

The chord of Fig. 73 is divided into five parts, and Fig. 75 into twelve parts, and all are drawn as shown by the dotted lines.

VASES.

As vases are sometimes used for terminal for gables, pedimentas, &c., the author has thought it advisable to give the proper proportions of the half of two and the method of describing them.

For the sake of clearness all lettering has been avoided, but the striking points have been thickly dotted for the body of the vase, and if a little thought be given to the

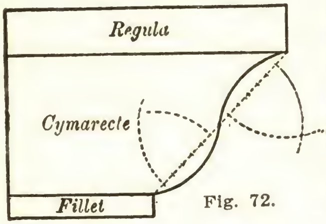

Fig. 72.

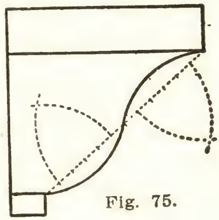

Fig. 75.

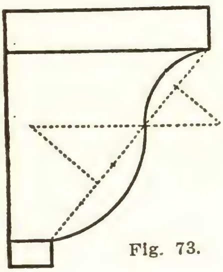

Fig. 73.

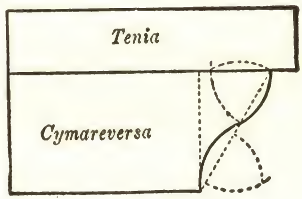

Fig. 76.

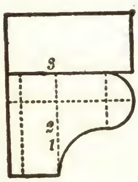

Fig. 74.

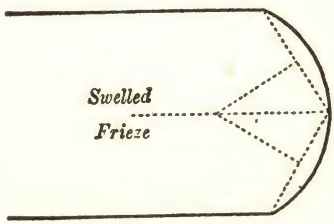

Fig. 77.

other lines there need be but very little difficulty in describing the whole of the parts.

The proportions for enlarging them are given on the centre perpendicular line, and from this perpendicular

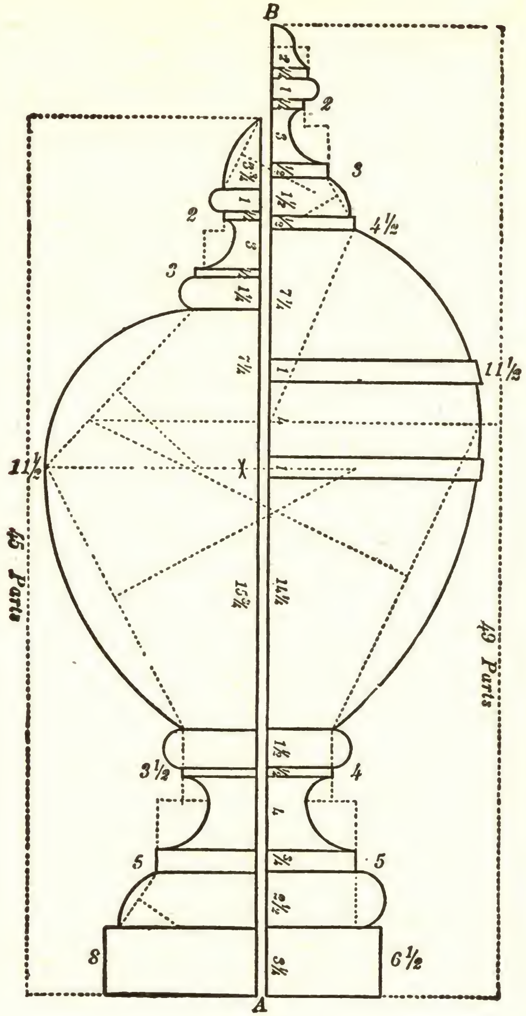

Fig. 78.

(which may be termed an imaginary line running through the centre) for the side projections. So that whatever height the intended vase may be, it must be divided into the number of parts given on the height line, shown on each side of the figure.

In cutting the vase, every course should radiate to the centre, and on the plan for working each projection should have its own circle, so that the plan will simply be a series of circles from the greatest to the smallest diameters of the vase. Set out on the largest circle the

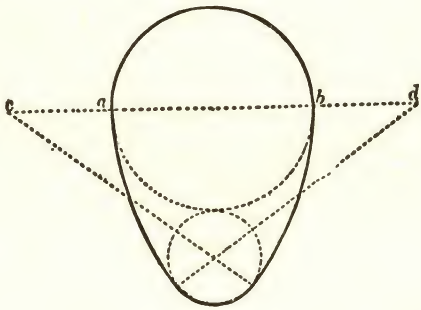

Fig. 79.

width (taking care to make all the courses headers) and draw lines to the centre, so that all cross joints shall radiate and the perpends be kept upright. Let all bricks be squared in the full length of the bed, and also each cross joint. The vase should be solid, even if it is intended to work the inside hollow afterwards.

Put the work together somewhat near the shape required with patent knotting and lead, with a suitable iron rod running through the centre from A to B (Fig. 78); then obtain a box as described for the sphere or ball,

and place the work so that it will turn as if in a lathe; and after having two moulds made to a section, as shown in the figure, and fastened on the sides of the box exactly opposite and level with one another, and keeping the line A B level with the centre of the rod passing through the vase the latter can be turned until it is level at all parts with the sectional mould. If the vase is a very large one there is no reason why it should not be made and turned in parts with the same section moulds, and with the parts marked on them.

THE EGG-SHAPED SEWER.

This is frequently used, and is considered the best shape that can be adopted for sewers, both for its convenience for scouring and cleansing, and also as being well adapted to resist the pressure of the earth from without.

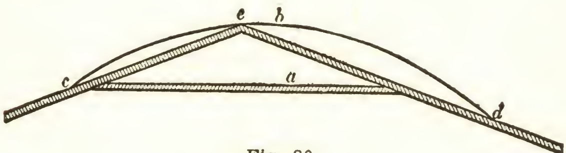

Fig. 80.

The following proportions will be found to answer for any size, and have the double advantage of being very simple and very exact, so that no difficulty can be found in applying them.

Supposing the greatest width from *a* to *b*, Fig. 79, is 2 feet, this will be the diameter of the circle of which the top is the half. The diameter of the smaller circle is half that of the greater; this gives the proportionate size of the bottom, and its position also. Then, in order to ob-

tain the sides, or connecting lines between the two circles, set off half the greatest diameter on the outside of the figure, as *a c* and *b d* (on the horizontal line), and draw the dotted lines from these points through the centre of the small circle; then *c b* will be the radius for one side, and *d a* for the other.

To describe a Segment of a Circle without a Radius.

Fig. 80 shows a simple method of describing any segment of a circle, from a camber to a semicircle or circle, without a centre or radius rod.

Assuming the height or rise to equal *a b* and the springing *c d* draw a line from *c* to *b* and *b d,* and let the angle at *b* be the trammel, allowing one side to be as long as the span of the arch or width of the required segment; the other need be only half this length. Drive nails in the drawing-board at *c* and *d,* and by holding the pencil at *e,* and keeping the trammel close to the nails *c d,* that part of the segment from *c* to *b* can be accurately described. Reverse the trammel and describe the part from *b* to *d.*

If it is preferable, and the sides of the trammel are both made the width of the opening, the whole arc from *c* to *d* can be struck at one operation. And an ordinary set square will, if applied in the same manner, accurately describe a semicircle or circle.

There is an evil in setting out several arches by means of a mould fitted to the curve of the soffit of one, which has led many into trouble.

Suppose there were a great many camber arches to cut for openings of various sizes, it has frequently been thought that if a mould is struck out to the largest one,

it will also apply to those that are not so wide; but this is wrong. An opening 4 feet wide, rising an eighth of an inch in the foot, will give half an inch for the total rise; but one 2 feet wide, taken from the middle of the same mould, will not give the quarter inch which it ought to have, nor nearly so much. Therefore it ought always to be a rule that a separate striking should be made for every different opening, not only the cambered ones, but for any other segment or part of the circle.

REMARKS ON MATERIALS, ETC.

Bricks for Cutting and Building.

Unfortunately the old adage of "penny wise and pound foolish" is followed out to the letter in the building trade quite as much as in any other trade or profession, and particularly so in the choice of bricks. Builders generally think, if they can save a little per thousand in the purchase of bricks, that they have effected a considerable economy where a great many thousands are required. Well, of course that would be so if no loss were incurred in the use of them, but where the workman is required to make good face work, then mere cheapness of cost, apart from quality, becomes a great evil and loss.

It is often stated in the specifications of buildings that the bricks are to be of a certain class and of a uniform color. Well, it is possible to have an inferior brick of the sort named, but it is seldom that we can get them all of the same color or squareness, for the superior bricks are generally picked from the others, principally on that account, and where the inferior kinds are used the workman in laying them often turns over a dozen bricks before he can get one that will suit the work, thereby losing the time that he would be employed in laying them if they had been good ones.

Again, there is not the care taken in the making and burning of cheap bricks that there is with the good ones, so much so that when they are sent in they are as a rule bevel-headed, hollow, or cambering on the side, so that the second course can never be laid with a level bed on

the first, and the face of the brick kept upright with the face of the wall. Therefore it often occurs that the bricks are kept close down at the tail, and without any bed at all, so that they may show a plain surface on the particular part exposed to view. This makes very unsound work, besides the extra labor involved in its execution; and when buildings are being erected with many piers and angles the labor lost in picking square bricks is something very serious, and none know the extent of this evil better than those who have found it out by painful practical experience. Where a man would lay a thousand good bricks in a specified time he would not lay five hundred bad ones. This surely is of considerable importance where a great many men are employed, and especially so when we remember that work which ought to cost three pounds per rod will with bad bricks cost six, and then be not nearly so good.

Of course the above remarks do not apply to foundations or any kind of work that is buried in the ground or plastered, for in such cases the shape of the brick is not so much an object as its soundness. One would think, therefore, it would be far the cheapest and best plan to give the little extra per thousand and have the good bricks, which seldom have these faults. The foregoing remarks apply principally to stocks, common reds, and malms. The gault and perforated bricks have not usually such faults, although the common ones of these even very often have one face hollow and the other just as much cambering, so that when built it is a very difficult matter to get the face of the wall to its plane surface, and few things look worse than to see it with one brick projecting and the other just as much hollow.

In gauged work or any kind of brickwork that is cut

to templates or moulded in boxes, the evil of inferior bricks also exists, but in a different form. The shape of the brick is a small object in this case, but the quality is everything; therefore too much care cannot be taken in the choice of them.

It is of very little use to look at the outside of a brick-stack if one is trying to ascertain the quality of the bricks, for very often the best of judges may be deceived by so doing. The brick must be broken, or, what is perhaps better, a few picked out of the stack indiscriminately and sawn through with the saw, so as to examine the kind of earth of which it is made; for we frequently see bricks having a first-class appearance outside, and the inside when examined is found to be full of stones or clay that has never been properly worked up, much less washed; so that when the cutter begins to work he is sure to find one or the other defect just in that particular part which he wants to cut the mould, and so the brick is wasted after a considerable time has been spent in squaring or otherwise preparing it for cutting, and the brick is not only wasted but the labor also.

There are a great many different kinds of bricks used for cutting, called "rubbers." Some of these have too much clay and others too much sand in their composition. The first takes a great deal more labor in working than would be required if the sand and clay existed in proper proportions, because there is not sufficient friction when working on the rubbing stone or using the saw, and the latter is almost as bad in the too great freedom of its working; for where the brick has too much sand it is next to impossible to work the angles to the sharpness generally required for good gauged work, the excess of sand making the brick rotten, as it were,

so that the angles will not hold. This is sometimes seen with good bricks, but it is when they have become exposed to damp and then dried by a fire. This is often the case in the winter season. When good bricks are obtained for cutting, too much care cannot be taken in preventing them from getting wet before they have passed through the cutter's hands.

The advantage to be gained by using good bricks (rubbers) is that instead of it taking ten bricks to the foot (which is often the case through the breakages), the same amount of work can be done with eight, sometimes seven, and never more than nine; and a man would cut four feet with good bricks in the same time that it would take him to cut three with bad ones, particularly in the case of small work—that is, arches that are brought down very thin at the soffit.

Mortar.

In building constructions there are few things of more importance, and thought less about, than the mortar, either as to the quality of the materials or the manner of mixing them, and where the mortar is made by hand, instead of making any improvement in this respect, very often we get worse. Competition is carried on to such an extent, and we are always in such a desperate hurry, that we cannot stop to mix the mortar properly.

There is no one to take an interest in it, although it is the staple of the edifice, save the laborer or "mortar buffer" who makes it, and usually he has to make sufficient for double the number of bricklayers that he ought, if he were to do it in a proper manner. Therefore, sometimes one bed is made with too much sand, and another with too much lime; one is very nearly all water

and the other just as stiff; and more often than otherwise the mortar is brought to the bricklayers to use, when the lime in it has not had time to properly slack itself, and the result is that when it does, the mortar is covered with the powder and is as dry as a chip. Then it has to be "worked up," as it is called, on the scaffold. This is a very poor system. There has been an improvement in many of the large firms of builders by the use of the mill, but nevertheless the majority still cling to the old style of mixing it by hand. Of course many small builders have not sufficient work to employ a mill, but others have, and yet cannot clearly see the advantage of its use. It is very evident to all who have anything to do with building, that the more the materials used are mixed up together the better, because each portion of lime will then receive an equal share of the sand and water. The lime is first slacked with a moderate amount of water and turned up in a heap, which is covered over with a thick layer of sand, sufficient for the quantity of lime slacked. The heat from the lime dries the sand, and the sand keeps the heat in the heap, so that the slacking process is more complete. After a time, when the lime is cool enough, the whole is turned over two or three times so as to thoroughly mix it; then all is sifted or screened together, and made into mortar. This is allowed to lie perhaps two or three days, after which it is turned over and beaten with wooden beaters about 6 feet long by 3 inches by 2 inches.

A good deal has been said and written of late about using hot mortar, but if many of those who thus write could see and examine work that has been built with mortar mixed in the above manner there is no doubt which of the two would obtain their appreciation.

However, the mill, if properly managed, is after all the best, on account of its having no waste and allowing many kinds of material to be ground into mortar which would be thrown away in the other case. For instance, all limestones and sandstones are thoroughly crushed into one mass, so instead of the stones in the sand being an evil, they are, when crushed, an improvement to the quality of the mortar, and with the lime and sand form a miniature concrete.

Again, in buildings of almost any kind there is a great deal of waste in bricks through cutting them to suit the different classes of work. There can be no reason why these should not be ground up, for they will rather improve the quality of the mortar than injure it; and lastly, there is the advantage of having fine mortar, which is very rare when there is no mill.

It is a general practice to build brickwork with four courses to the foot in height. With many bricks this will not allow more than a quarter or three-eighths of an inch to a joint, and sometimes not that. To do this is a difficult task when it is remembered that in nineteen cases out of twenty the sand itself is passed through a screen having meshes no smaller than three-eighths or half an inch. It is done, however, but at a very great loss to the builder, for when the bricklayer spreads a bed to receive the brick it is not an unusual occurrence for him to lay and take it up again time after time on account of the stones in the mortar preventing him from bedding the brick to the line.

Hundreds of cases have been known where one brick has been laid and taken up again to pick the stones out of the bed, four, and even five times. Now what is

there to prevent the workman from laying just as many bricks while he is doing this?

Of course there will be a little more loss from the sand if screened through a finer screen than there otherwise would be; but this is always useful for ballast, so that actually there would be but little or no loss in that way.

Where it is proposed to burn the earth taken out of the cellars and trenches, to make burnt ballast for grinding to mortar; great care is needed, as the soil is so different in one locality from that in others. Some soil will yield a firm and compact clay, and others a chalky marl. The former is good for the above purpose, but the latter is very deceptive, and will destroy all the properties of the lime or cement mixed with it, even in a worse form than when mixed with clay in its natural state, and that is bad enough.

Artificial Stone.

In a former work was given a short description of the method then adopted in making this material. And when we consider the thousands of tons annually used, the improvement in its manipulation, and its merits, both for durability and fire-resisting properties, it surely has further claims to our consideration.

The casting of this material does not always belong to the bricklayer, as in some firms the plasterer does that part of the work, but it is always the practice to employ the former to do the fixing. The principal ingredients used in the making are Portland cement, coke breeze, sand, and shingle; but coke breeze is the all-important item, as without that in all probability the last would soon be heard of it.

There is no doubt of artificial stone being well adapted for floors, partitions, steps, lintels, &c.; but for ornamental casting for outside decorations, where the work is required to be finished with the accuracy obtainable with stone or gauged brickwork, it is scarcely as cheap as either, nor nearly so beautiful in finish; for the labor required in making the moulds to the requisite degree of accuracy, also in casting, and in touching up the work before and after fixing, more than equals that expended on either stone or brickwork: therefore if there is any gain at all it must be in the material, which of course is cheaper.

It is usual to cast all face work in blocks a convenient size for hoisting and fixing, according to the class of work of which they are to form a part. The moulds are made with every moulding inverted, and the sides and ends should be made movable, so that they can be taken away from the block when it is well set, without turning the latter out of the position in which it was cast. The sides should be made to project 2 or 3 inches beyond the ends, and grooves made in them to receive the latter. The sides are then held perfectly tight to them (while being filled) by means of iron bolts and nuts at each end, one near the top and the other close to the bottom, but outside the mould. In cases where the block is a long one, it is sometimes necessary to insert other bolts through the middle, so as to keep the sides from bulging out with the pressure upon filling the mould.

For outside work, both plain and ornamental, the facing is done with washed sand and Portland cement, in the proportion of two parts of the former to one of the latter, if the work is to be finished with a face the color of cement; but if it is to represent stone, an oxide of

iron is used. This being of a beautiful red color, and having very strong coloring properties, a small quantity goes a very long way; so much so, that for facing purposes, if mixed in the proportion of thirteen parts of Portland cement to one part of oxide, it will give a very fair representation in color of the above-named stone. This oxide is obtained from various chemical works. Before wetting these ingredients, they should be well mixed dry. This is best done by first washing the sand and then drying it, so that it will pass through a fine sieve; then, to get the proper proportions, let a box be made 24 inches by 17¼ by 8¾; this will contain just a sack of cement; and a smaller one, 9 inches by 7 by 4¼, which will be the size of a box that will hold the proper quantity of oxide for the above quantity of cement. Then take two boxes (large) of sand and mix with the oxide and cement; turn them over twice and sift the whole through the fine sieve. This is then gauged up (not too soft), and after the inside of the mould is oiled with linseed-oil, place the composition all round the sides and bottom of the mold and fill in the middle with rough stuff, which can be gauged as follows: three parts of coke breeze, one part shingle that comes from the washed sand, and one part of Portland cement; this should be put into the mould carefully with a hand float, so as not to force the coarse stuff through the facing: if so, the work will need a lot of patching afterwards.

Iron rods, about three-eighths of an inch square, are placed lengthways in all blocks exceeding 2 feet in length to add to their strength, as the filling up process goes on. The facing ought to be half an inch in thickness at the least.

For face work that is not colored the cement and sand should be mixed and worked in the same way.

Steps are made in this way, only with a little more Portland cement.

For floors, 2½ sacks or 5 bushels of Portland cement to a yard of coke breeze is the usual proportion.

The manner of making the supports, &c., to receive the concrete is as follows:—

Iron joists are placed across the room or area to be floored over, say 2 feet apart, with at least 4½ inches bearing at each end and in section, according to the length of the room. For large works the strains must be carefully calculated, but in small cases—say, for anything under 12 feet in the clear—4 inches by 2 is sufficient for living rooms, the strength varying according to the amount of weight placed on the floor.

A platform is then formed underneath these joists to receive the concrete while in a soft condition. This is formed by nailing brackets to the two opposite walls of the room about 4 feet apart (these brackets are about 15 inches long, wedge-shaped, so that two can be cut out of a piece of quartering 4 inches by 3 inches), and laying pieces of 3-inch by 3-inch quartering on them, one piece for each side, and others to take the middle bearings 4 feet apart also, in the same way as plates are placed on sleeper walls for ground floors. Then place cross bearers of the same scantling about 2 feet 6 inches apart, to answer as joists, and cover the whole with inch boarding; and if the latter is kept three quarters of an inch below the iron joist the breeze concrete can be kept under them so as to form a level ceiling to receive the plastering. The whole is then filled up level with the top of the iron joist, taking care the concrete is not too

wet, and also that it is well beaten down with a heavy hand float.

Fig. 81 is a section showing the method usually adopted for effectually completing the concrete floor. The brackets at *c* are nailed as shown, *b* is the joist, and *a a* the struts for supporting the floor in the middle of room.

Breeze bricks, for fixing door-jambs, window-frames, skirtings, &c., instead of using wood bricks, or slips, are made with more breeze and less cement, and will, when properly made, form the best fixing known.

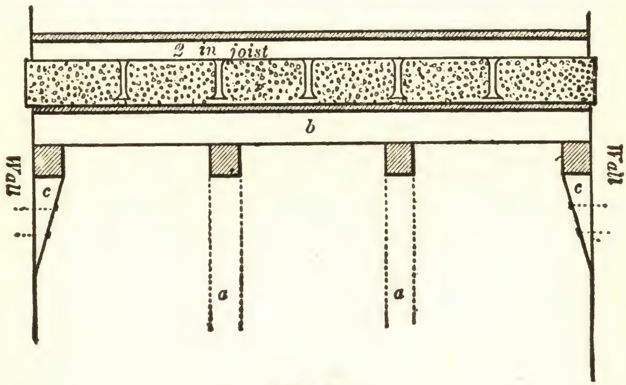

Fig. 81.

Partitions. These are used in preference to wood on account of the material being fireproof, and in preference to brick for economizing space. They are made in slabs the height of the room, in length and width convenient so as to fill out the length of the partition, say about 3 feet, 2¼ inches in thickness, with a groove on one edge and a tongue on the other.

For the casting a movable platform is made, the same as for an ordinary floor with 3-inch by 3-inch joists, 15

inches apart, and large enough in length and width to receive the slab and a piece of cleared wood 2¼ inches by 3 inches, screwed to the platform to the width required to form the groove and tongue, and also a piece at each end to form the top and bottom.

The middle of the box thus formed is then half-filled with coke breeze and cement, and three-eighth inch iron rods placed diagonally and length-wise as ties. A channel is then formed with the breeze and cement, and filled in with soft cement or cement and washed sand, so as to form a good edge for fixing the slabs together; but those edges that come against doorways, &c., must not have this cement edge, otherwise it will be useless for fixing the door-frame, as no nail will enter it; but let the edge be finished with the same concrete as the body of the slab is made with.

The boxes are oiled previous to being filled, and when the slab is cast and set sufficiently hard, one of the wood sides is taken away, and the platform is turned up so that the slab slides off on to its edge to dry.

In fixing the slabs in position, two pieces of iron are fixed in the floor, projecting out so as to form dowels for the bottom of the slab. The latter is then reared upright upon them and fixed at the top with wood wedges. Each joint is then stopped in and grouted, and all is made good with cement before the wood wedges are taken out.

When all is set, it is usual to hack them on both sides to receive the plastering, and unfortunately this is generally left until the last; but it would be much better if this hacking were performed as soon as the slab leaves the mould. It could be very easily done then, and would never break the joints of the partitions afterwards.

The proportions for casting the above are two and a

half parts of coke breeze to one of Portland cement, and when dry it weighs 110 lbs. to the cubic foot.

The material for face work varies, but is about 120 lbs. to the cubic foot.

Lintels. The same kind of material as used for floors is also applied to lintels, by forming a casing with three boards, and filling it firmly in with the concrete, at the same time bedding two or three iron rods lengthways as a tie.

THE BOW-SAW.

There is nothing connected with cutting that has caused a greater revolution during the last few years

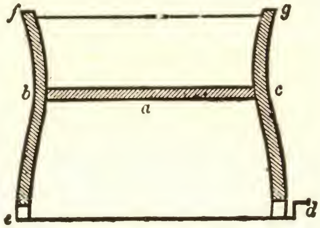

Fig. 82.

than the bow-saw. Whether for boxing mouldings of any description, reducing bricks for ashlar or arches, cutting scrolls, or any and every kind of work, the bow-saw is the most convenient invention. In fact, the cost of labor connected with gauged work has been reduced vastly by its use, and a short description may be found useful here for those who have not been in the habit of using it. The frame is best made of some tough wood that will bear the strain, and the lighter the better, such as straight-grained Honduras mahogany, willow, poplar, ash, or beech, but the latter are rather heavy.

The upight sides should be about 16 in. long, and 1½ in. by ⅞ in. in section, and the crosspiece *a* Fig. 82, about 2 feet in length, the same thickness as the upright sides. This is morticed loosely into the latter, and held in its place by means of a screw, but not tightly.

This completes the woodwork, and as regards holding and tightening the wire, there are a great many different opinions. Some prefer to have the wire twisted before it is fixed to the frame; others to fix it in the frame and twist it there.

If the latter way is adopted there must be a small winch attached at the bottom of the frame at *d*, and a small shaft running through the latter, with a hook to receive the wire. This wire is then fastened to a nail or screw at *e* brought under that end, and fastened to the hook of the shaft running through the end *d*. Then if a plain piece of 3-16 wire is made to run through the top *f g*, and fastened with a nut or thumbscrew, the winch can be turned, and the wire twisted and tightened at pleasure.

If the wire is twisted before it is fixed in the frame, the tightening is done either by a piece of strong string and a windlass (such as carpenters tighten their bow-saws with), or by means of two small rods of iron, each running about half-way across from *f* to *g*, with a thread worked on them in the centre or where they meet, and so loosened or tightened by means of a "union"; and this method, if properly constructed, is not to be despised.

While working the saw, in moulding or reducing bricks in boxes, both hands are used, one to hold each side, but not working to and from the body as with other saws, but from right to left. When lengthening the brick, work it to and from the body.

The box is held in position by means of a piece of 2-inch batten, cut to fit tight between the box and the roof of the shed, which can be removed at pleasure.

The method usually adopted for twisting the wire is as follows:—

Take a piece of wire, say 40 feet, double it, and hook one end into a hook or nail, and pull the double wire out straight; pass the other end through a piece of gas pipe and fasten it round a piece of wood (about ¾-inch diameter) in the middle. Then, holding the piece of gas pipe with the left hand, and keeping the wire straight, turn the wood round until the wire is sufficiently twisted. It can then be coiled up ready for use.

MENSURATION OF GAUGED WORK.

In a former work a few simple rules were given by which decimals and duodecimals could be applied to the mensuration of brickwork.

Assuming that the reader has made himself practically acquainted with those rules, it is thought desirable that this knowledge should be somewhat extended, so that he should be able to measure any description of work, whatever it may be, that comes under the heading of gauged work.

Therefore, well knowing the need of this, and the advantage that it gives to the workmen, I shall endeavor to give a few simple and concise methods, for obtaining both the superficial and the solid contents of some of those forms such as will assist him (if only in a small degree) in arriving at the desired result.

1. *To find the superficial and solid contents of a sphere or globe.*

A sphere or globe is a round solid body every part of which is equally distant from a part in the middle called the centre.

To find the superficial contents, multiply the diameter by the circumference, the result will be the superficial area, and product multiplied by one-sixth of the diameter will give the solid contents. This rule can be applied to the mensuration of the niche-head, when it is necessary to measure it accurately; also to domes, by first taking the whole and afterwards dividing by 4 or 2 as the case may be.

Example. Suppose a globe is 24 inches in diameter, its circumference will be—

```
      7543 nearly.
        24 diameter.
    ------
     30172
    15086
    ------
    181032 superficial area.
         4 (= 1-6 diameter).
    ------
   7241.28 cubic inches.
```

being the solid contents.

2. *Supposing a niche head to be 2 feet 6 inches at the springing line of the face, how many superficial feet are there in the soffit?*

This being a quarter of a globe, dividing the whole by 4 will give the area of the soffit. First obtain the circumference thus.

```
      7 : 22 :: 2.5
           2.5
         -----
           110
           44
         -----
       7)550
         -----
         7.857 circumference.
           2.5 width of opening.
         -----
         39285
        15714
        ------
     4) 196425
        ------
        4.9106
```

Therefore 4 9-10 feet or 4 feet 10¾ inches is the area of the soffit of the niche.

3. *To find the superficial area and solid contents of a cylinder, or any figure such as a column.*

The circumference multiplied by the length will give the circular area, and by adding to this the area of each end the whole of the superficial contents will be obtained. But for the solid contents, square the diameter and multiply by .7854 to obtain the area of one end, and this multiplied by the height will give the solid contents.

Thus, suppose a column to be 11 inches in diameter and 7 feet in height; according to the table given on the next page we find this 11 inches is represented by the decimal fraction .916 of a foot. Therefore—

```
          .916
          .916
          ----
          5496
          916
        8244
        ------
        .839056 square of diameter.
          .7854
        -------
        3356224
       4195280
      6712448
     5873392
    -----------
    .6589945824 area of end.
              7 height of column.
    -----------
   4.6129620768 = 4 feet and 6-10,
   ============
```

or 4 feet 7¼ inches as the solid contents. Or, for obtain-

ing the area of the end, multiply half the circumference by half the diameter, which will give very nearly the same result, and in the present case would be much easier.

4. *Table of decimals of a foot, showing how any number of inches and half inches are represented as decimal parts of a foot.*

These are calculated as nearly as possible without running them out to a great number of parts, which would never be used in brickwork.

Inches.	Decimals of a Foot.	Inches.	Decimals of a Foot.
½	.041	6½	·541
1	.083	7	·583
1½	.124	7½	.624
2	.166	8	.666
2½	.207	8½	·707
3	.25	9	·75
3½	.291	9½	·791
4	·333	10	.833
4½	.274	10½	.874
5	.416	11	·916
5½	·457	11½	·957
6	·5		

5. *To measure an arch circular on plan.*

Take the length of the outside semicircle at the extrados of the arch for one dimension, and the depth of the face for the other, and multiply them together for the area; then take the length of the soffit by putting the tape on the front arris by the depth of the reveal. This will give the area of the whole arch.

6. *To obtain a square equal in area to a given circle.*

If the diameter of any circle is multiplied by the decimal .8862, or the circumference multiplied by .2821, the products will equal the side of a square of equal area.

To find the area of the space between two circles one within the other, or concentric circles, Fig. 83. The sum of the two diameters multiplied by their difference, and

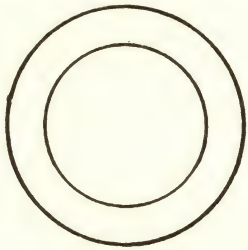

Fig. 83.

by .7854, equals the area of the space contained between them. Thus, in the example given the outer diameter is 30 and the inner one 20. To find the area—

$$\begin{array}{rl} 30 & \\ 20 & \\ \hline 50 & \\ 10 & \text{the difference.} \\ \hline 500 & \\ .7854 & \\ \hline 392.7000 & \text{the area.} \end{array}$$

7. *To find the contents of a pyramid.*

Multiply the area of the base by one-third of the height for the solid contents, and the length of each side

added together by half the height for the superficial area. The area of the two ends of the frustum of a pyramid added together and divided by 2, and that product multiplied by the perpendicular height, will give the solid contents.

8. *To find the contents of a cone.*

The area of the base multiplied by one-third of its height will give the solid contents, and half the circumference of the base multiplied by the length of its slant side will give the superficial area, and adding to this the area of the base we shall get the total surface.

9. *To measure an ellipse.*

If the two diameters of an ellipse are multiplied together, and that product by .7854, the result will be its superficial area. Thus, suppose the greater diameter to be 35 inches and the less 25 inches—

$$\begin{array}{r} 35 \\ 25 \\ \hline 175 \\ 70 \\ \hline 875 \\ .7854 \\ \hline 3500 \\ 4375 \\ 7000 \\ 6125 \\ \hline 687.2250 \end{array} \text{ total inches.}$$

Or by dividing by $144 = 4$ feet $9\frac{1}{4}$ inches.

10. *To measure an arch in form of an ellipse.*

Take a mean between the long and short rustics, as x, for the greater and less diameters, and proceed as above described; then take the two soffit diameters and treat

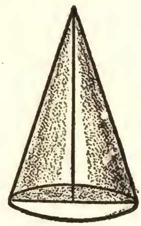

Fig. 84.

them the same, and subtract the less area from the greater: the product will be the area of the face. Add the side projections of the rustics beyond the face and

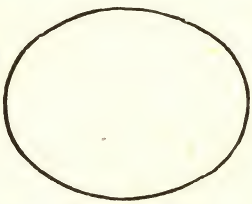

Fig. 85.

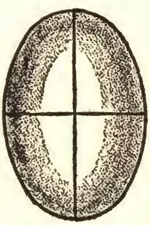

Fig. 86.

the round of the soffit multiplied by its width after to complete the measurement.

11. *To find the contents of a spheroid.*

A spheroid is a solid formed by the rotation of a semi-ellipse about one of its axes which remains fixed. An

oblate spheroid is such as would be formed by the revolution of an ellipse about its shorter axis; and an oblong spheroid, one that would be formed by revolution about its longer axis.

Rule. Multiply the square of the revolving axis by the length of the fixed axis, and the product by .5236 for the solidity.

Thus, suppose the length of the revolving axis to be 33 (inches or feet) and the fixed axis 55—

```
      33
      33
      --
      99
     99
    ----
    1089 = square of revolving axis.
      55 = fixed axis.
    ----
    5445
   5445
   -----
   59895
     .5236
   --------
    359370
   179685
  119790
 299475
 -----------
 31361.0220 total solidity.
```

12. *To find the superficial contents of an elliptical dome.*

To find the superficial contents of the above, or such as Fig. 44, multiply the diameters of its base together, and the product by 1.5708 for the contents, and the re-

sult will be sufficiently correct for all practical purposes. Of course, in Fig. 45 before given, the circular chimney must be deducted from the dome and taken separately.

13. *To find the area of a parabola.*

One of the conic sections.

Rule. Multiply the base by the height, and two-thirds of the product will be the area.

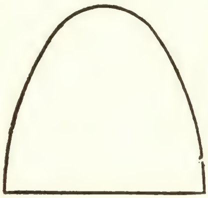

Fig. 87.

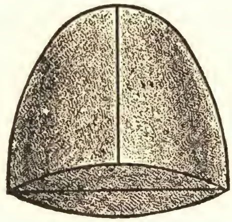

Fig. 88.

Thus, required the area of a parabola whose height is 6 and the base 12.

$$\begin{array}{r} 12 \\ 6 \\ \hline 72 \\ 2 \\ 3)\,144 \\ \hline 48 \text{ area.} \end{array}$$

14. *To find the contents of a parabolic conoid.*

Rule. Multiply the square of the diameter at the base by .3927, and that product multiplied by the height will give the solid contents.

Suppose the diameter of the base to be 5 feet 6 inches and the height 18 feet—

```
    5·5
    5·5
  -----
    275
   275
  -----
   3025 = square of base
     ·3927
  ---------
     21175
     6050
   27225
   9075
  ---------
   11879175
         18 height
  ---------
   95033400
  11879175
  ---------
  213.825150 total = 213 feet 9¾ inches.
```

Another way is to multiply the area of the base by half the height, and the product will equal the contents; or the solidity may be obtained by taking two-thirds of its circumscribing cylinder.

15. *To find the superficial area of the frustum of a cone.*

Rule. Add the circumference of both ends together, and multiply half the sum by the slant height, to which add the area of both ends for the total superficies; the area of both ends added together and divided by two, and multiplied by the perpendicular height, will give the solidity. Or, the squares of the diameters of the two ends added to the lengths of the two diameters, and that

sum multiplied by its height and by .2618 equals its solidity.

16. *To find the radius of a circle of which a segment is given.*

The sum of the square of half the chord of a segment, added to the square of the versed sine or rise, and di-

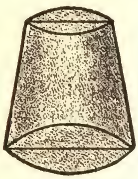

Fig. 89.

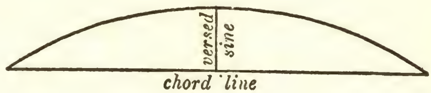

Fig. 90.

vided by the rise, will give the diameter of the circle, half of which is the required radius.

Suppose an opening to be 43 inches wide, and the rise of the soffit of the arch above the springing line or chord to be 4 inches, thus—

```
           21.5
           21.5 half the chord
          ------
           1075
           215
          430
          -------
          462.25 = square of half chord
           16    = square of rise or versed sine
          -------
rise    4)478.25
          -------
        2)119.56 diameter
          -------
           59.78 radius.
          =======
```

So the radius will be a fraction over 59¾ inches.

TERRA-COTTA.

Terra-cotta is a material made from a refractory brick-earth, carefully selected and prepared; it is usually moulded into blocks, and built to represent ashlar work, being made up to 18 inches in length. The size of blocks of terra-cotta should never be made to exceed 4 cubic feet; undoubtedly blocks the contents of which do not exceed 1 cubic foot are much to be preferred.

Composition. The following shows the composition of a typical specimen of terra-cotta:

Silica	75·2
Alumina	10.0
Sesquioxide of Iron	3·4
Calcium Oxide	1.2
Magnesium Oxide	trace
Alkalies and Alkaline Chlorides	·5
Water	5·9
Organic Matter	7·7

It will be seen by the large amount of silica and the small percentage of alkaline matter present that the clay will be refractory, the quantity of the latter being just sufficient to cause a vitrified skin or surface, to which the material owes its durable qualities. The quantities of oxide of iron present, varying from the above amount to 10 per cent, impart the shades of pink and red common to terra-cotta.

Manufacture. The material is carefully ground, strained and pugged, and, to avoid excessive shrinkage

in drying, sand, ground glass, or pottery is sometimes added. The mixing must be conducted with great care to ensure uniformity throughout the mass.

The material is moulded, carefully dried, and then baked. The two latter operations must not be accomplished in a hurried manner, or the material will twist.

The terra-cotta blocks are not made solid, but are built up hollow, the thickness of the sides varying from 1 inch to 2 inches, and have diaphragms or partitions connecting the opposite sides for their support. By this arrangement great thicknesses of the material are avoided, the drying is facilitated, and the surfaces and the interior are more uniform, thereby avoiding fractures, which would otherwise ensue.

In moulding the blocks, the thickness of the sides should be made of the same material throughout, and not made in two layers, as has been done, to economize the fine clay by placing a thin layer in front and using a coarser and inferior material on the back; the unequal contraction causes the two layers to separate.

Color. The color varies with the temperature at which the clay is baked, and with the percentage of oxide of iron present. Color may be imparted by giving the clay a wash of ochre paint before baking. This is inferior, soon wears, and should not be resorted to.

Fixing. Terra-cotta blocks, when built in walls or anywhere to withstand pressure, have their voids filled up with ordinary Portland cement concrete; this usually causes discoloration due to the cement concrete working through. A filling composed of Portland cement and ground terra-cotta is more effective. The voids are left hollow in floors or any position where lightness is desirable.

Moulded work in terra-cotta, owing to the unequal shrinkage in drying, often becomes slightly twisted, which in buildings with a long run of cornice or string mouldings has a bad effect. This is often corrected by chiseling parts of the face; but it should not be allowed, as, if the vitrified surface skin be destroyed, the remainder will rapidly disintegrate under the influence of the weather.

The dimensions of the blocks are usually some multiple of brick dimensions, in order to bond with the brick backing.

Terra-cotta is most suitable for decorated panels, statuary, and work which would have to be carved if in stone, especially where these have to be reproduced several times.

STONEWARE.

Stoneware is prepared from clays, consisting of silica and alumina, with a small percentage of iron, calcium, etc.

The clay is prepared in a similar manner to the brick-earth, usually being mixed with a proportion of ground stoneware or sand to avoid excessive contraction in burning.

The articles are moulded by various processes, and burnt in a domed kiln; the material is practically non-absorbent, but to ensure this the articles are glazed.

The glazing is performed by adding sodium chloride (common salt) when in the kiln, which is volatilised by the heat, and in the form of a vapor is decomposed by the silicates of alumina, with which it combines to form a glass, the chlorine passing off from the kiln.

The sodium chloride in the form of a vapor penetrates into all the pores of the stoneware, completely covering the surface with a coating of glass.

This material is chiefly used for such articles as drain and sewer pipes, damp-proof courses, or any position where a damp-resisting material is required. These are burnt in kilns at a very high temperature, and when finished are thoroughly vitrified throughout their whole thickness.

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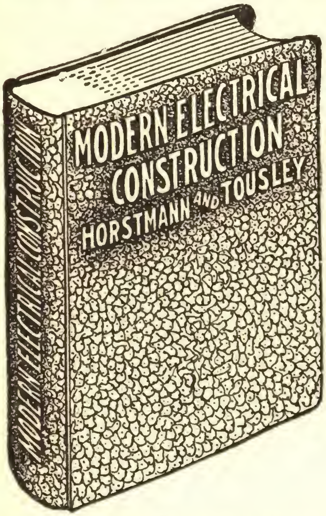

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